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INTRODUCTION

This manual is the result of the Leonardo da Vinci project titled: **Improving Vocational Education in the Construction Industry Sector with the aim of Identification and Recognition Qualifications in European Union Countries 08-LdV/TOI/02059/013**.

Polish Association of Construction Industry Employers – Poland was the promoter of the project.

Partners of the project: Polish British Construction Partnership Sp. z o. o. – Poland, CREDIJ (Centre regional pour le développement la formation et l'insertion des jeunes) – France, University of Minho – Portugal, Ufficio Scolastico Provinciale di Venezia – Italy, Econometrica Ltd. – Greece, The Chartered Institute of Building – United Kingdom.

PROCONSTR is a project concerning developing an innovative program of vocational training based on eight selected construction professions for graduates from vocational schools, technical secondary schools, and employees who are professionally active and want to increase their skills.

The aim of the job modules is to promote the idea of regular vocational development, support activities leading to implementation of European tools concerning education and vocational training – equalisation of opportunities on European labour markets, intensification of cooperation among companies from construction sectors and social organisations in order to promote vocational development with reference to EQF and ECVET in the Europe.

Moreover the project's challenge is to make participants in the training sessions more aware of the requirement to increase their vocational qualifications with regular training sessions, as well as learning new techniques and technologies that are utilised in the construction industry and language education. Once these skills have been gained it will give them the opportunity of being employed across the European Union.

Unification of essential regulations of vocational qualifications in European Countries might simplify easy transfer of the most modern technologies as well as enabling common usage of knowledge and generating new employees that are able to meet the requirements of contemporary European market.

The nature of the training sessions is directed at men and women, with supporting efforts heading for equal opportunities to access to vocational education and to ensure equality on the labour market, in this case, giving special consideration to the construction branch.

The outcome of the project is an innovative didactic resource for beneficiaries. Eight job modules were created on the basis of data collected and domestic markets available. The didactic materials were created with support of construction companies on national levels.

- **Job Module for Bricklayer**
- **Job Module for Carpenter**
- **Job Module for Plumber**
- **Job Module for Electrician**
- **Job Module for Concrete builder**
- **Job Module for Roofer**
- **Job Module for HVAC worker**
- **Job Module for Plasterer**
- **Module for trainer**

Each job module consists of two parts with the first part being theoretical, including the latest know-how concerning specific trades necessary for employees. The second part consists of training with appropriate examples set out in exercises based on chosen innovative aspects.

The project's creators hope that the final product has a long-term influence which can be utilised successfully in vocational education throughout the European Union. The use of a unified course of vocational training in all countries would result in elimination of formal and informal barriers concerning easy-flow of employees and equalize differences in professional qualification levels.

Equalization of qualifications between European countries would result in the effective exchange of experiences; simplify identification of different types of problems (in less developed countries) and the implementation of preventive means.

Conclusions drawn from the executed project could be used to create new training solutions as well as to prepare vocational education system reforms on a domestic level.

More information on project website: www.proconstr.eu.

Chapter I METHODOLOGY OF TRAINING

System of training

Training is to be carried out over three days in groups of up to 20. The first day is theoretical training, the second and third days encompass practical and theoretical tests aimed at testing participants' knowledge.

Theoretical training on the first day involves 6 classes (45 minutes each) and two breaks of 10 minutes and a 30-minute lunch break.

The second and third day will cover practical training on site - 6 classes at 45 minutes each. Practical training will be summed up with a specially prepared final test. Breaks are scheduled as shown on the first day. Once the final test has been passed, the participant will receive a certificate, which confirms the participant's expertise in a given subject.

Purpose of training

The purpose of the training is to make participants familiar with innovative construction technology, making use of new products entering the market, appropriate tools and equipment. During the training, participants will be informed about new products, possibilities and relevance of its application. The participants will receive full information and guidelines with regards to using the technology. During the on-site part of the training, the participants will have the opportunity to find out about the advantages of the new system under the supervision of a qualified trainer.

The testing module is used to test the knowledge and expertise obtained during the course of the training and will be confirmed with a relevant certificate.

Course of training

First day of training:

- presentation by a lecturer,
- presentation of beneficiaries,
- presentation of the training program with a brief description of issues included in the theoretical part and the system of exercises within the practical part.

Theoretical training program includes:

- introduction to a subject-matter - assumed form of a lecture / multimedia presentation,
- presentation of selected new technologies presently applied in the construction industry,
- presentation of selected products,
- discussion over selected products or systems posing the training subject,
- presentation of tested products' and technical parameters,
- presentation and discussion over tools or equipment applicable in a system,
- discussion over type of structure which can be carried out with a particular technology,
- discussion over recommendations,
- multimedia presentation of a presented system,
- general discussion.

Chapter II INTRODUCTION TO THE SUBJECT THEME

Introduction

Analyzing the construction industry, it must be said that constructing is a complex form of architecture and town planning activities which end products are new developments i.e. buildings and structures of any kind (industrial, road, Infrastructural). This area also covers renovations of construction resources in all fields of national economy. It provides a large scale of tasks for the construction industries to be completed. Every construction worker will face those tasks in everyday work.

It must be emphasized that the construction industry covers public construction, industrial construction, housing construction and civil engineering construction. The construction industry is considered to be one of the largest sectors of industry with around 8% of total workforce employed in the industry. This sector is varied, providing employment for specialists from many diverse fields, relying on economic cycles and climatic conditions since many works are carried out outdoors. It requires the workers to be mobile, ready to move (depending on the area where work is to be carried out) and continuous improvement of professional skills because the construction technology constantly develops.

New technologies are continually introduced in order to facilitate construction works and the opportunity to develop more interesting architectonic designs, which force constructors to look for new technical and material solutions. Employment term depends on the timescale of construction. Being a construction worker is a difficult job with a high ratio of accidents. Hence the emphasis on Health and Safety training and observing H & S regulations when performing construction works at the site.

Construction process

The notion of construction process is something that a construction worker deals with on a daily basis. The construction process is a complex and multi-stage activity, encompassing all phases of construction starting with an initial concept, feasibility study, design, construction works and ending with construction commissioning and going live. The main participants of any construction process are the developer, construction supervision engineer, designer and construction manager. Each of the aforementioned persons is responsible for an appropriate stage of preparations and construction of a development.

Developer

The developer is responsible for organising the construction process, including Health and Safety procedures and provision of:

- preparation of a construction design and other designs if necessary,
- taking charge of a construction site by a site manager,
- drawing up a Health and Safety plan,
- completion and commissioning the construction works,
- supervision of a competent specialist in case of complicated construction works or difficult ground conditions.

Construction development engineer

The main responsibilities of a construction development engineer are**:**

- representing the developer of the site by controlling the conformity of works with the design, construction permit, regulations and engineering expertise,
- checking the quality of works, inbuilt construction materials, preventing faulty products and products without a relevant certification from being used in construction works,

- taking part in tests, technical commissioning of installations, technical devices, chimney ducts, preparation and taking part in commissioning of completed developments for final commissioning,
- confirmation of actual works, elimination of defects and, on the developer's request, controlling of financial aspects of construction works.

Construction site manager

A construction manager is obliged to, based on Health and Safety information and specification of a designed development as prepared by the designer, draw up or facilitate drawing up of a Health and Safety Plan, taking into consideration the specification of the construction and conditions in which construction works are to be carried out, including construction works and industrial production to be performed at the same time.

Main responsibilities of a construction manager are:
- a written handover and proper protection of the site together with structures, technical devices and fixed points of geodesic matrix as well as protected elements of natural environment and cultural heritage,
- maintaining construction documentation,
- provide geodetic setting out of the structure, organising and managing the construction of the structure in accordance with the design, construction permit and Health and Safety regulations,
- co-ordination of activities aimed at preventing health and safety accidents,
- preparation of technical and organisational assumption of planned works or its stages to be carried out simultaneously or subsequently,
- planning time needed to complete construction works and its stages,
- co-ordination of activities which encourage and help to observe Health and Safety procedures during construction works,
- introduction of necessary changes in information on Health and Safety and the Health and Safety plan resulting from the progress of construction works,
- taking all necessary actions preventing unauthorised persons from entering the site,
- stopping construction works in case of an emergency and informing competent authorities of any situations,
- informing the developer about an entry in the construction log with regards to construction works being incompatible with the design,
- compliance with recommendations entered into a construction log,
- preparation of "as-is" documentation of the construction – after works accomplishment,
- commissioning of the construction with a relevant entry in the construction log and taking part in commissioning activities and assuring that all defects are eliminated and handing over a declaration of conformity that the construction works have been carried out in accordance with a construction permit and regulations in force and a declaration that the construction site has been cleared, together with adjacent roads, buildings or premises.

Health and Safety

It is evident that one of the most important issues in the construction industry is ensuring that workers directly involved , work in a safe environment to enable them to carry out works without any problems or danger. A worker must not carry out works in conditions which are hazardous, detrimental to health and where sanitary conditions are below required standards. Each worker must undergo a relevant training induction and be made familiar with manuals and typical tools used for a work place. Health and safety instructions must be placed in social facilities and each worker is obliged to observe such instructions.

Environmental protection

Each worker employed on the construction site must undergo an environmental protection training session, during which they will have the opportunity to be familiarised with environmental protection regulations. In the course of construction works, each worker must keep order in his workplace and construction site, paying attention to reduce noise when performing works, reduce emission of gases and dust to prevent air pollution, observe safety precautions and fire-preventing regulations.

Chapter III BRICKLAYER PROFESSION

Presentation of an innovative system of erection of walls and building structures - method of a lecture associated by multimedia presentation.

Part I – theoretical lecture

Job description

A bricklayer is a profession consisting of carrying out the bricklayer's works, which means all sorts of bricked structures, and all related works.

Presently, a bricklayer does not brick foundations or carry out lintels (with exception of arcs) or bricked ceilings. This type of structure is met just during repairs and dismantling. Therefore, detailed information is not required anymore. A contemporary bricklayer makes walls of ceramic hollow blocks or lime-sand blocks, consequently, he/she should know the aforementioned technologies perfectly well. Presently bricked walls are made of a light cellular concrete. Interlocks eliminate the head joints in a wall which means less consumption of the mortar and acoustic insulation of walls is much better. One can freely arrange the interiors. Used materials are non-flammable, forming a safe and friendly house. Resistance to the humidity eliminates the necessity for use of a waterproof insulation. All of these technologies must be well-known to a bricklayer. Also system tools necessary for construction works are more and more frequent instead of traditional bricklayer's tools.
A bricklayer's job, due to a huge progress of materials is simpler and more effective.

Scope of bricklayer's tasks

Scope of tasks carried out by a bricklayer is very wide. The job is classified as a heavy job (physical job) and most of the tasks are carried out manually. The basic tasks of a bricklayer include:

- arrangement of work position – description of performing works,
- knowing and selection of construction materials – (basic and supportive ones) – choosing appropriate materials, transportation and storage,
- use of tools, devices and building equipment, which do not require additional authorisations,
- reading of technical documentation,
- carrying out of erection works in accordance with the art of buildings, valid codes, technical conditions and works commissioned,
- carrying out of other general construction actions,
- carrying out of surveys, cataloguing measurements and bricklaying works survey,
- preparation of required materials and material settlement lists regarding the job position,
- using devices, equipment and technical and social facilities on the site,
- rating of the building materials quality and correctness of works being done,
- solving of characteristic technical and technological issues on the work position,
- laying tiles, levelling, stone, marble and ceramic ones,
- communication and cooperation within the team on the site,
- providing the first-aid.

Presentation of product

Wall elements – blocks and tiles

Carrying out of a wall's element is essential. No matter whether this is a block or a hollow brick, apart from purely technical parameters of a material, their accuracy and shape are significant.

Manufacturing accurate wall elements of cellular concrete brings opportunity of accurate bricklaying. If wall elements have tongues and grooves, the face joints are not filled. Profiled hand grips are used to simplify the process of transporting blocks.

Mortars

Depending on used wall elements, one may carry out a casual or thin-layer mortar. A casual mortar is related to inaccurate traditional wall elements. Due to a mortar up to 15 mm thick it is possible to level the unevenness of a wall.

Thin-layer mortar means a higher level of performance. In such cases one may use only accurate elements and relevant tools.

If one disposes with profiled elements then the head joints are not filled with a mortar. It is a great advantage which accelerates completion of works. This also means less technological humidity in a building at the stage of construction.

Presentation of used technologies which shorten time necessary to carry out an investment

Discussing opportunities regarding using innovative materials.

In light of requirements, provisions, market situations and simple technologies, which shorten the time necessary to complete, an investment is very popular. There is a system building with use of cellular concrete and modern mortars. Opportunities produced by use of a modern material such as the cellular concrete are great. Bricklaying is carried out with use of simple manual tools and is very simple. Preferably, one should use an entire system which means blocks, masonry, mortar, elements of lintel, U profiles, tiles, tools and other elements.

Due to its great properties cellular concrete is a good material to use to erect single and multi-layer walls. Optimally it matches the most significant properties which should characterise a wall: compressive strength, thermal insulation and fire resistance. Additionally, it is characterised by a low volume mass which makes it useful for the needs of manufacturing elements (e.g. blocks) of large dimensions, keeping all principles of ergonomics.

Additionally, the system elements which means a selection of elements adjusted to each other brings high opportunity for complex carrying out of a building. This means serious safety level and simplification for investors, contractors and designers.

What is advantage and innovativeness of some of technologies and system?

In order to prove advantages and innovativeness of some of technologies, a short presentation of available solutions is necessary.

Such a system consists of many elements matching each other, such as: blocks, tiles, profiles, lintels and supplementing elements. All elements are 240 mm high and are characterised by the same dimensional tolerance which is 1 mm. The system also consists of tools necessary to lay bricks with use of a thin joint.

Advantages of new system in construction works – topic development:

- erection of buildings,
- quality work improvement - quick erection compared to other technologies,
- adjustment of various elements to individual needs,

– laying bricks with use of a thin joint,
– types of walls erected by means of system discussed.

Presentation of products' technical parameters

Wall elements are series of relevantly shaped pre-fabricated units to erect walls. Names depend on sizes and scope of use.

Blocks – topic development:

– types of blocks and scope of usage,
– practical use of various blocks,
– external walls carrying,
– internal walls carrying.

Table no. 1 Assortment of blocks with tongues and grooves.

Density class	Width [mm]							
	60	80	120	180	240	300	360	420
400					X	X		
500					X	X	X	
600					X	X	X	
700								

Table no. 2 Assortment of plain blocks and tiles.

Density class	Width [mm]							
	60	80	120	180	240	300	360	420
400								
500			X	X	X	X	X	
600	tiles	tiles	X	X	X	X	X	
700			X		X			

Tiles – topic development:

– types of tiles,
– tiles usage in single-layer external and interior walls.

Masonry mortars - topic development:

– types of mortars,
– advantages and disadvantages of mortar usage.

Casual mortars – topic development:

– types of traditional mortars,
– traditional mortars preparation – specific recipes,
– range of usage.

Adhesive mortars - topic development

– advantages of thin-layer adhesive mortars usage,
– presentation of types of walls carrying by means of thin-layer adhesive mortars,
– description of adhesive mortars preparing.

Table no. 3 Water usage

Type of a wall	wall thickness [cm]	use of a mortar in kg – dry mixture	quantity of water per 1 kg of dry mixture [liter]	quantity of water per 1m2 of a wall [liter]	wall area [m2]	quantity of water in a building (in walls) [liter]
A wall made of cellular concrete with a thin joint	24	3	0,25	0,75	300	225
A wall made of cellular concrete with a thin joint	42	5,3	0,25	1,325	300	398
A wall made of cellular concrete with a casual joint	24	25	0,14	3,5	300	1050
Tiny elements, e.g. ceramic ones with casual mortar	24	50	0,14	7	300	2100

It seems clear that with the use of a casual mortar, compared to thin-layer one, use of water is 5 times lower.

Thermo insulating mortars

To erect single-layer walls, light mortars are used as well. Light mortars are recognized to be thermo insulating ones. They are mixed with foamed polystyrene, pearlstone or expanded clay.

Thermo-insulating mortars may be prepared of ready-to-use mixtures packed in tight bags. It is enough to mix them with water. Bricklaying with the use of thermo-insulating mortars is generally not different from a classic erection process with use of traditional mortars.

Out of the mortars, thermo-insulation is two times worse than insulation rates of bricked elements. Due to the addition of the pearlstone or granulated foamed polystyrene, or expanded clay, such mortars are more expensive than thin-layer mortars, which is why this sort of mortar is rarely used and is slowly disappearing from the market. Although this is the only correct manner of bricklaying in case of inaccurate elements, these mortars enable preserving quite good parameters of thermal insulation of the entire wall.

Development of mortars

Foam adhesives have been developed and manufacturers purposely use the 'mortar' name in relation to the above mentioned products, although the products are based on polyurethane. This is done in order to associate them with their intended use which is bricklaying (a mortar is a mixture on the cement base). Foam mortars in cans simplify bricklaying works, but only under some conditions and with the use of relevant elements.

At the moment these sort of mortars are being tested in terms of their durability, behavior under dynamic loads and how they are affected by high temperature and fire.

Presentation and discussion over bricklayer's special tools used to cellular concrete – topic development

Discussion over type of structure which can be carried out in a particular technology.

Walls in the building play a series of important roles i.e. transfer loadings, insulate thermally and acoustically and protect from humidity. In other words they are very significant.

There are many opportunities to erect walls. They can be single-layer, multi-layer with insulation, or triple-layer with facing. All opportunities must result in the correct carrying out of part of a building.

One system, many opportunities

Single-layer wall – topic development:

- presentation of erect single layer walls without insulation,
- discussion about insulation parameters of the blocks.

Multi-layer wall made of cellular concrete blocks - topic development:

- presentation of materials and techniques used to erect multi-layer walls,
- types of multi-layer walls,
- multi-layer walls elements – presentation.

In case of both solutions it is significant to exercise due diligence and observe a few principles in terms of performance. It shall enable optimally use advantages of cellular concrete, accelerate bricklaying works and eliminate mistakes.

Works preceding bricklaying - topic development:

- casting foundation walls,
- use of a levelling instrument to level the upper layer of foundation walls.

Discussion over bricklaying works, step by step

Horizontal insulation of the ground floor walls – topic development:

- presentation of horizontal insulation – ways of application,
- horizontal insulation usage: using an insulation foil or torch-on membrane.

Insulation with foil - topic development:

- insulation foil usage,

- advantages of insulation foil usage,
- the ways of insulation applying by means of foil.

Insulation with a torch-on membrane – topic development:
- advantages of torch-on membrane – foundation insulation preparation,
- foundation insulation preparation by means of torch-on membrane.

Erection of the first layer – topic development:
- base course erection,
- base course parameters,
- face of the ground wall that should be projected beyond the face of foundation walls – specific parameters,
- bricklaying first layer of blocks on cement mortar,
- bricklaying of blocks in the corners of a building,
- preparation of cement mortar,
- preparation and applying of adhesive mortars.

Internal walls erection – topic development:
- internal walls carrying principles.

Erection of other layers – topic development:
- base preparation,
- blocks grinding,
- brushing the dust,
- mortar applying.

Carrying out of corners – topic development:
- keeping appropriate order during erection of corners,
- always coupling non-profiled areas of blocks with a mortar.

Carrying out subsequent layers of wall – topic development:
- discussion about carrying out subsequent layers of blocks,
- highlight applying specific tools during carrying out the works.

Coupling of an external wall and internal wall – topic development:
- discussion about coupling of an external wall and internal wall,
- highlight the fact that external walls must be cut in such a manner to have a space in a wall which is 15 cm deep.

Erection at holes – topic development:

– discuss the ways of reinforcement of the zone under windows,
– discuss the ways of reinforcement to door holes or end of a wall,
– importance of strengths and tensions distribution.

Other element of a wall – topic development:

– ways of methods of erection pillars made of U profiles – step by step,
– applying insulation materials.

Lintels made of autoclaved cellular concrete – topic development:

– various types of applying lintels – parameters, application.

Table no. 4 Exemplary list of parameters of pre-fabricated lintels

Reinforced lintels							
Symbol of lintel	**Dimensions [cm]**			**Weight of element [kg]**	**Maximal width of hole to be covered [cm]**	**Length of support [cm]**	**Maximal balanced computable load [kN/mb]**
	Length	**Width**	**Height**				
NS 140 / 12	140	12	24	35	100	20	22
NS 160 / 12	160			40	120	20	16
NS 200 / 12	200			53	150	25	15
NS 230 / 12	230			61	180	25	12
NS 140 / 18	140	18		50	100	20	27
NS 160 / 18	160			58	120	20	19
NS 200 / 18	200			75	150	25	16
NS 230 / 18	230			86	180	25	13

Note:

If over the lintel there is a reinforced concrete rim the load capacity is by 50% larger.

Additional conditions, which must be met to assume larger load capacity:

- Distance between a lintel and a rim must not exceed half the space of a hole to be covered,
- The rim must have 0,025m^2 at least, required by a code,
- The rim shall be made of concrete, class C16/20 (B-20) at least,
- Upper reinforcement of the rim shall made of two bars ϕ10 at least, class of steel A-I St3S-b at least

Other manners of carrying out a lintel – topic development:

– carrying out of a lintel by means of U profiles,
– applying pole-form supports.

Finishing works – topic development:

– appropriate type of plaster applied to blocks made of cellular concrete,

– specific plaster covering methods,
– thickness of the external plaster,
– ceramic tiles applied.

Multi-layer wall thermal insulation – topic development:

– insulation layer fixing system presentation,
– types of insulation layers,
– types of elements which enable to pin insulation layers to walls.

Conclusions

Conclusion of this course will be answers to questions about using presented system (mortars along with blocks):

– What is the advantage of using thin layer and thermo insulating mortars?
– What is the advantage of using cellular concrete blocks - dry joint method?
– What is the innovative in this methods and system in all?
– What are the differences between traditional and innovative methods of bricklaying?
– Does this presented system influence the quality of work improvement?

Presentation of the system / 8 minutes training movie/

Discussion

Part II – practical exercises

(2 days)

Implementation and discussion over particular tasks by an instructor. Then, the teams shall carry out tasks by themselves, controlled by an instructor.
Dimensions of erected walls to be discussed. Height of the wall should not be higher than a person erecting it. Dimensions of a wall should enable plastering them, carrying out of fixtures, adhering foamed polystyrene and carrying out of grooves

Required tools and devices:

– wall elements: blocks, lintels and mortar, depending on number of teams,
– plasters, adhesives, grid adhesives and lathing,
– sets of tools depending on number of teams: (relevant width trowel, mixing unit, bucket, manual saw, guide, long float and rubber-face hummer),
– drill to mix the mortar,
– to apply plasters and adhesive, some long floats with teeth shall be necessary as well as plain ones depending on number of teams,
– access to water and current is necessary (with a few sockets); the need to remember to keep all necessary materials within a hand's range.

Practical show of bricklaying – by an instructor – and discussion over subsequent actions:

– presentation of particular elements, which shall be used for exercises,
– mortar preparation,
– laying and adjusting of blocks, including corner blocks,

- system of applying dry mortar,
- wall erection,
- holes erection.

Practical exercises of training participants / 3-person teams

Independent carrying out of basic jobs supervised by an instructor:
- preparation of mortar,
- wall erection,
- first layer (on layer of a foil and casual mortar).

Erection of other layers with consideration given to :
- correct re-erection of blocks,
- correct re-erection of walls,
- correct cutting of the blocks,
- correct carrying out of a lintel,
- block cutting,
- correct use of relevant tool.

Applying a layer of foamed polystyrene to a wall with the use of adhesive and pins.

Inspection of works carried out by the instructor.

<u>Independent bricklaying controlled by an instructor /3-persons teams</u>
Presentation – by the instructor, on a single position, rules of re-erection of walls, angle different than 90 degrees, half-round wall erection, application of selected plasters.

Inspection of works carried out by the instructor.

Summary of workshops, FAQs, remarks and conclusions.

Practical test

Independent carrying out of a selected element of structure of blocks.
Credit and rate of completed works (by instructor).

Test part

1. When erecting blocks with tongues and grooves, should one fill the head joint with a mortar?
   a) Yes
   b) <u>No</u>
2. May a ‘comb’ trowel be used to erect with use of a thin joint?
   a) Yes
   b) <u>No</u>
3. How many blocks of dimensions: h: 24 x w.: 24 x l.: 59 cm are required to erect 1m2 of a wall?
   a) 8,33 pcs
   b) 10 pcs
   c) <u>7 pcs</u>
4. What simplifies masonry works?
   a) <u>Use of a system</u>
   b) <u>Use of relevant tools</u>
   c) Erection with use of thick joint
5. What is the correct allocation of head joints in a wall?
   a) <u>0,4h, where h means height of an element</u>
   b) 2 cm at least
6. Erection of the layer should start from:
   a) Center of a wall
   b) <u>Corner of a wall</u>
7. A first layer of blocks, which is erected on a foundation wall, should be erected with the use of:
   a) <u>Casual mortar, previously applying a layer of horizontal insulation</u>
   b) Thin-layer mortar without a horizontal insulation
8. Can the thin-layer mortar be applied with a casual trowel?
   a) <u>No as even and thin layer will never be obtained</u>
   b) Yes
9. Is it correct to lay down blocks with a mortar applied in a few points only?
   a) <u>No</u>
   b) Yes
10. Is a circular saw blade necessary to cut the cellular concrete blocks?
    a) <u>No. blocks may be cut due to manual saw</u>
    b) Yes, specialist tools are required
11. Does one need to fill in the hand grips with a mortar?
    a) <u>No</u>
    b) Yes
12. When coupling partition walls and carrying walls with metal couplers, the couplers must be fixed into the joint:
    a) into each layer

   b) <u>into every third layer of blocks</u>

13. What is used to set out a straight line of an erected wall?
    a) <u>A rope within a line of erected wall</u>
    b) Ruler
14. Spirit level is used to:
    a) Measure a distance
    b) <u>To find levels</u>
15. To stabilise and correct localisation of cellular concrete block one may use:
    a) Construction hammer
    b) <u>Rubber face hammer</u>

Chapter IV CARPENTER PROFESSION

Part I – theoretical lecture

(1 day)

Before You start the training:

- you will need a beamer, a lap top computer with PowerPoint application and a screen or white wall,
- prepare the presenters view of the presentation on Your computer, watch all the animations and read the slide comments,
- if You have any samples of wood materials (plywood, timber beams, carpenter tools) and examples of assembly drawings prepare them earlier,
- you can print plywood and assembly pictures from the "Additional information…" part,
- prepare blank tests for all the participants to fill as an opening and a closing test,
- do a brief summary of the historical aspects of carpentry and future outlooks given in chapters I-IV,
- go through the presentation together with the participants.

Additional information for theoretical and practical part, subjects for discussion:

Trainer's main tasks:

- highlight all the different factors for choosing the right formwork type, construction (client's needs and wants against. what is possible and economically satisfying for both parties) and climbing solutions (does the client need the self-climbing solution, does the technology allow climbing at all.),
- describe the difference between all materials, when to use them and what advantages and disadvantages they have,
- explain the assembly sequence (as shown in the practical part),
- put the emphasis on the safety aspect of working with carpenter's tools,
- show the new safety trend for the sites and the need for carpenters in this matter,
- explain what are the most common mistakes whilst assembling the elements, what is the effect on the concrete surface and site activities and why is the quality control so important.

Material characteristics:

Plywood (if You don't have samples print out the photos below)

Every manufacturer gives different material characteristics due to wood type, construction and technology. The end finish of the wall or slab depends on the surface of the ply, but also on the swelling and shrinking properties of ply.

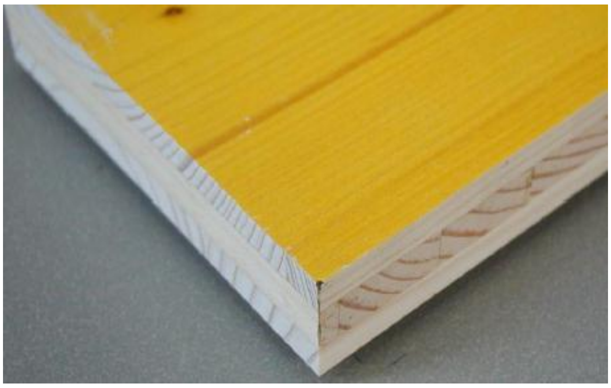
Properties of selected types of wood

Type of wood	Bulk density [kg/m³]	Coefficient of shrinkage*		Strength values [N/mm²]				Modulus of elasticity [N/mm²]	Resistance class (DIN EN 350-2)
		radial	tangential	Tension (axial)	Compression (axial)	Flexion (transverse)	Shear (axial)		
Spruce	470	0.15	0.32	80	40	68	7.5	10,000	4
Pine	520	0.15	0.30	100	45	80	10	11,000	3-4
Larch	590	0.20	0.44	105	48	93	9	12,000	3-4
Birch	650	-	-	137	60	120	12	14,000	5
Beech	690	0.19	0.34	135	60	120	10	14,000	5
Oak	670	0.15	0.26	110	52	95	11.5	13,000	2
Ash	690	0.19	0.34	130	50	105	13	13,000	5
Acacia	730	-	-	148	60	130	16	13,500	1-2
Acajou sipo	590	0.22	0.25	110	58	100	9.5	11,000	2
Azobé (ironwood)	1060	0.32	0.42	180	95	180	14	17,000	1

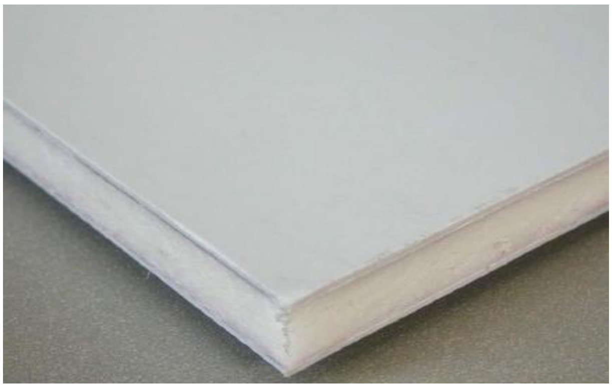
* The coefficient of shrinkage is the dimension change (in %) below fibre saturation per unit percent of reduction in wood moisture content.
The values quoted here are averages. Using wood and timber invariably entails allowing for high variation coefficients (between 10 and 22 %, depending on the property in question).

The 4 first types of wood are most commonly used, due to their low price and good mechanical characteristics.

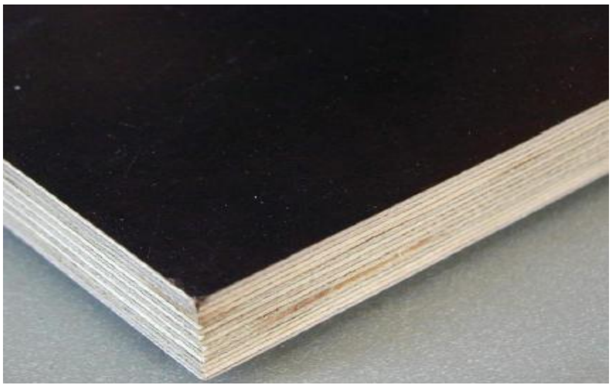
3-layer or 5-layer:



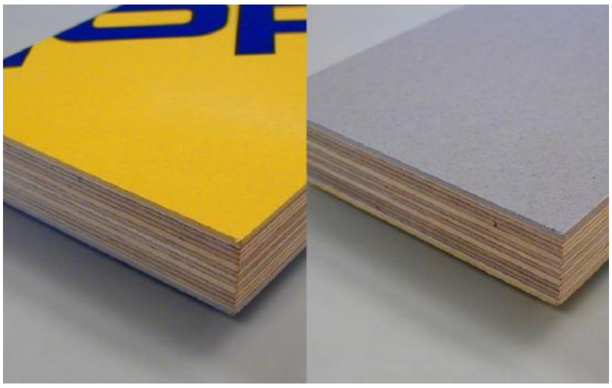
Plastic:



Multilayer (thin layers of wood glued together):

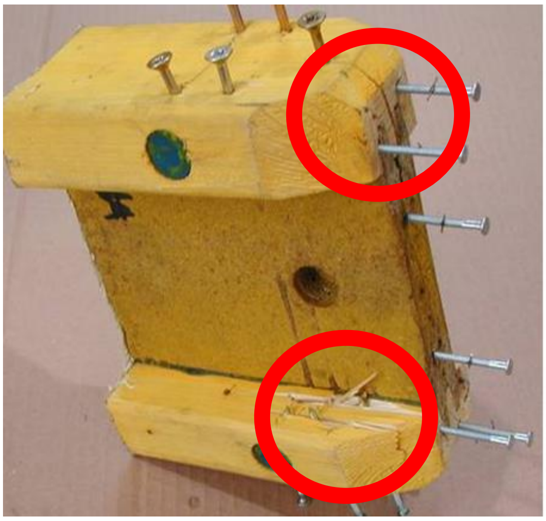


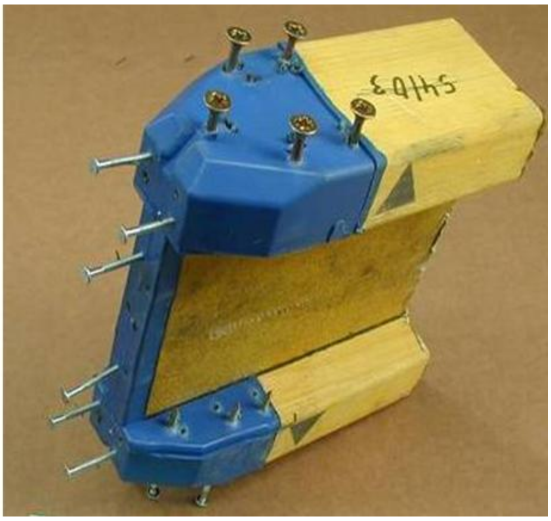
Composite (plastic surface, wooden core):



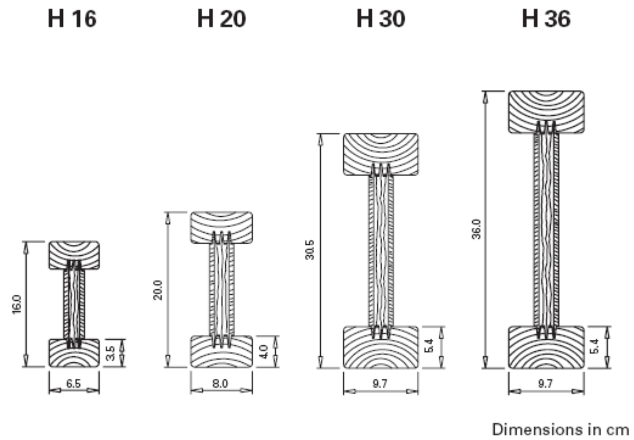
Structured (e.g. wooden boards imprint):

Timber beams:
If it's a H20 **P** beam, the web is lattice. If the name is H20 **N**, the web is solid. The technology of the web has no significant effect on the beams characteristics, it is a matter of using the rest material from the production process so it is cheaper and eco friendly.





Most manufacturers try to protect the ends of their beams (up to 80% of damages occur at the end part of a beam). This happens due to water penetration in the grain of the wood, swelling, shrinking, screws and nails being hammered into the ends of the beams, and most often due to hitting on hard surfaces (dropping beams on concrete while stripping the slab formwork).
Here are some characteristics of different full web timber beams.

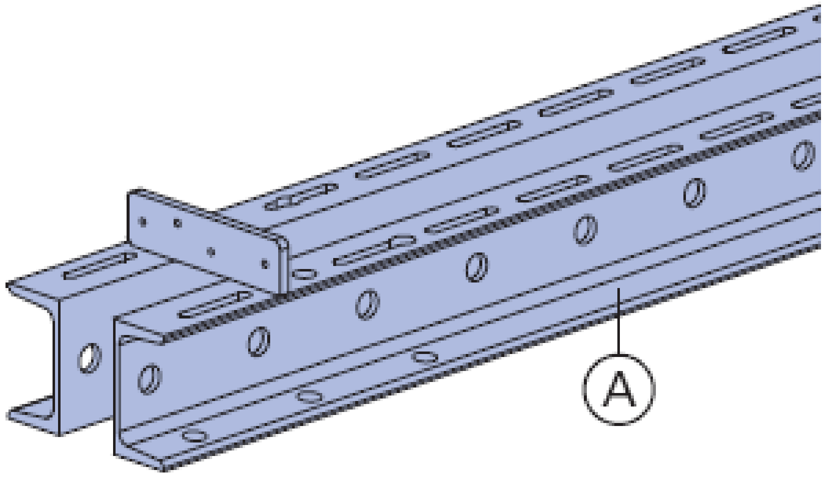


Design values

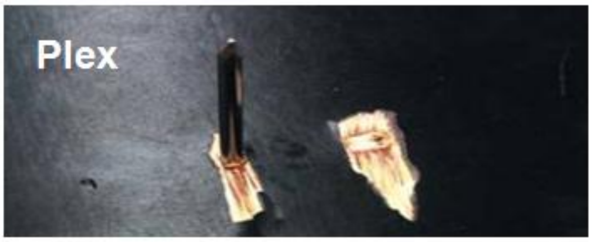
	H 16	H 20	H 30	H 36	
max. permitted Q	8.5	11.0	15.0	17.0	kN
max. permitted M	2.7	5.0	13.5	17.0	kNm
E x J	250	450	1250	1850	kNm²
max. support spacing	3.20	4.00	6.00	6.00	m

Steel profiles

Galvanized or powder coated steel is used for carrying concrete pressure to the tie-rods. There are two joined C profiles of heights between 10 and 14 cm. The bigger the profile, the stiffer it is and more force can be carried. All profiles have holes made in them, which are are used for attaching the accessories, beam-screws and joining plates.



New materials for timber beam formworks – main advantages and disadvantages:
Composite plywood (e.g. Xlife): plastic covering gives a smoother surface of the concrete. Wooden core makes nailing possible, but plastic covering enables the nails to be pulled out without plywood chipping the surface. The nail holes close themselves so that water from the concrete cannot penetrate to the core, and ply does not swell. This increases the lifespan of the plywood. So it lasts longer on the site when used properly, but is also more expensive.



Plastic plies: their lifespan is far greater than that of any wooden ply due to their weatherproof construction. They are completely resistant to moisture and heat, but do not often allow nailing and can crack from mechanical damage (i.e. hit hard against something).
Composite timber beams have the same handling easiness as normal timber beams, but bear up to 80% more momentum and carried forces. This is achieved due to the patented combination of plastic and wood. Less beams can be used in a formwork, although the beams are more expensive.

Sophisticated shapes:

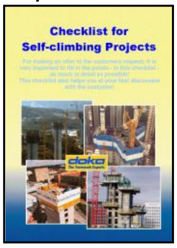
Climbing and self-climbing systems:

Climbing systems make the sites a lot safer (the outside formwork stands on a safe platform that can carry it and enables the workers to do the forming and concrete works as well as all the supplementary actions like concrete cosmetics in a safe environment).

With guiding systems, the moving process is still done by the crane, although platforms are attached to the building structure to make the process "windproof" (e.g. GCS – Guided Climbing System, Xclimb 60 guided solution).

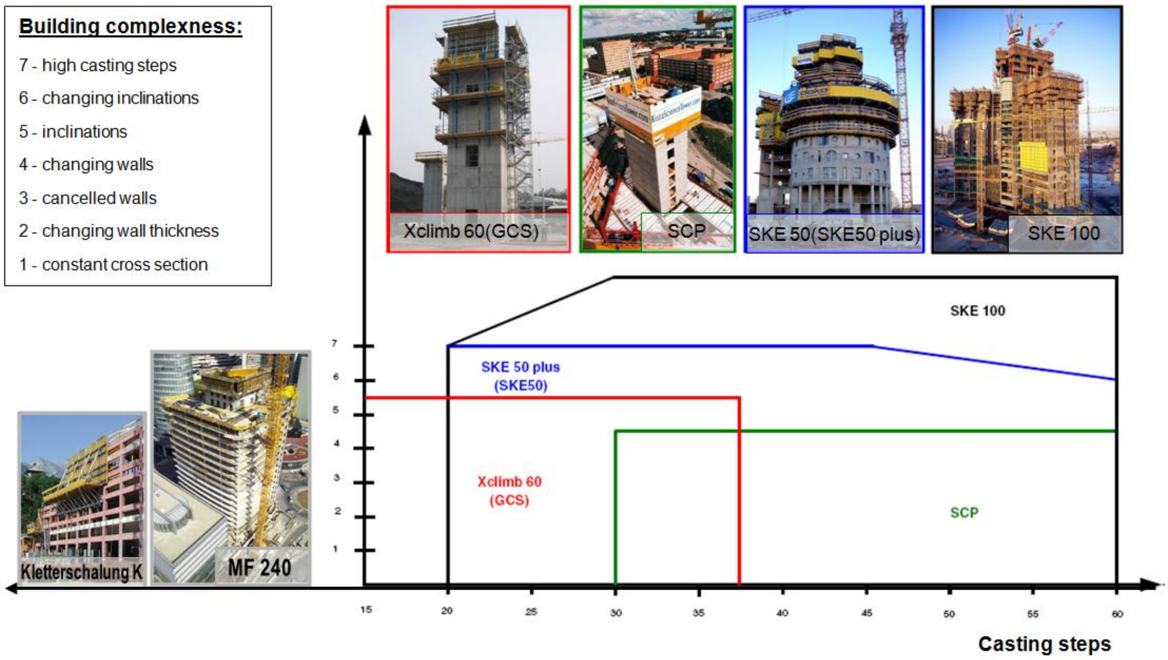
The main added value of self-climbing constructions is the time saving aspect (not only for the labor but also crane time – cranes can be used elsewhere).

Note: the number by the name of Doka systems (Xclimb 60, SKE 50, SKE 100) means the carrying capacity of a hydraulic cylinder resulting in the size of formwork a single platform can take. Other manufacturers have other naming conventions.



Because the systems are so complex it takes the knowledge of a specialist engineer (on both sides) to choose a system that fits the needs of the site (construction company and the system supplier). Information is gathered in the form of checklist.

The main criteria considered from a technical point of view is the height of the structure (number of casting steps), and the complexity of the structure (see the chart below).



Other implementations:

For high constructions (e.g. Burj Dubai) there is an obligation to use so called wind shields or protection screens. At larger heights the wind velocity is big enough to blow a man or loose building materials from the construction, so the whole building site must be surrounded protection screens.

$q_p(z_e)$ [kN/m^2] $v_p(z)$	$q_{b,0}$ = 0.32				$q_{b,0}$ = 0.39			
Höhe [m]	GK I	GK II	GK III	GK IV	GK I	GK II	GK III	GK IV
8	**0,83** 36,5 m/s 132 km/h	**0,70** 33,5 m/s 120 km/h	**0,50** 28,2 m/s 101 km/h	**0,37** 24,4 m/s 88 km/h	**1,03** 40,6 m/s 146 km/h	**0,86** 37,2 m/s 134 km/h	**0,61** 31,3 m/s 113 km/h	**0,46** 27,1 m/s 98 km/h
10	**0,88** 37,4 m/s 135 km/h	**0,74** 34,5 m/s 124 km/h	**0,54** 29,4 m/s 106 km/h	**0,37** 24,4 m/s 88 km/h	**1,08** 41,6 m/s 150 km/h	**0,92** 38,3 m/s 138 km/h	**0,67** 32,7 m/s 118 km/h	**0,46** 27,1 m/s 98 km/h
15	**0,95** 39,1 m/s 141 km/h	**0,83** 36,4 m/s 131 km/h	**0,63** 31,7 m/s 114 km/h	**0,46** 27,0 m/s 97 km/h	**1,18** 43,4 m/s 156 km/h	**1,02** 40,4 m/s 146 km/h	**0,77** 35,2 m/s 127 km/h	**0,56** 30,0 m/s 108 km/h
20	**1,01** 40,2 m/s 145 km/h	**0,89** 37,7 m/s 136 km/h	**0,69** 33,2 m/s 120 km/h	**0,52** 28,9 m/s 104 km/h	**1,25** 44,7 m/s 161 km/h	**1,10** 41,9 m/s 151 km/h	**0,85** 36,9 m/s 133 km/h	**0,64** 32,1 m/s 115 km/h
35	**1,13** 42,5 m/s 153 km/h	**1,01** 40,3 m/s 145 km/h	**0,82** 36,3 m/s 131 km/h	**0,65** 32,3 m/s 116 km/h	**1,39** 47,2 m/s 170 km/h	**1,25** 44,8 m/s 161 km/h	**1,01** 40,3 m/s 145 km/h	**0,80** 35,9 m/s 129 km/h
50	**1,21** 43,9 m/s 158 km/h	**1,10** 41,9 m/s 151 km/h	**0,91** 38,2 m/s 137 km/h	**0,74** 34,4 m/s 124 km/h	**1,49** 48,8 m/s 176 km/h	**1,35** 46,6 m/s 168 km/h	**1,12** 42,4 m/s 153 km/h	**0,92** 38,3 m/s 138 km/h
75	**1,30** 45,5 m/s 164 km/h	**1,20** 43,7 m/s 157 km/h	**1,01** 40,3 m/s 145 km/h	**0,85** 36,9 m/s 133 km/h	**1,60** 50,6 m/s 182 km/h	**1,48** 48,6 m/s 175 km/h	**1,25** 44,8 m/s 161 km/h	**1,05** 41,0 m/s 147 km/h
100	**1,36** 46,7 m/s 168 km/h	**1,27** 45,0 m/s 162 km/h	**1,09** 41,8 m/s 150 km/h	**0,93** 38,5 m/s 139 km/h	**1,68** 51,9 m/s 187 km/h	**1,56** 50,0 m/s 180 km/h	**1,35** 46,4 m/s 167 km/h	**1,15** 42,8 m/s 154 km/h
200	**1,53** 49,4 m/s 178 km/h	**1,45** 48,1 m/s 173 km/h	**1,29** 45,4 m/s 163 km/h	**1,13** 42,6 m/s 153 km/h	**1,88** 54,9 m/s 198 km/h	**1,79** 53,5 m/s 193 km/h	**1,59** 50,5 m/s 182 km/h	**1,40** 47,3 m/s 170 km/h

$q_p(z_e)$ [kN/m^2] $v_p(z)$	$q_{b,0}$ = 0.49				$q_{b,0}$ = 0.56			
Höhe [m]	GK I	GK II	GK III	GK IV	GK I	GK II	GK III	GK IV
8	**1,29** 45,5 m/s 164 km/h	**1,08** 41,6 m/s 150 km/h	**0,77** 35,0 m/s 126 km/h	**0,56** 29,8 m/s 107 km/h	**1,48** 48,7 m/s 175 km/h	**1,24** 44,6 m/s 161 km/h	**0,88** 37,5 m/s 135 km/h	**0,66** 32,5 m/s 117 km/h
10	**1,36** 46,6 m/s 168 km/h	**1,15** 42,9 m/s 155 km/h	**0,84** 36,6 m/s 132 km/h	**0,56** 29,8 m/s 107 km/h	**1,56** 49,9 m/s 180 km/h	**1,32** 46,0 m/s 166 km/h	**0,96** 39,2 m/s 141 km/h	**0,66** 32,5 m/s 117 km/h
15	**1,48** 48,6 m/s 175 km/h	**1,28** 45,3 m/s 163 km/h	**0,97** 39,4 m/s 142 km/h	**0,68** 33,0 m/s 119 km/h	**1,70** 52,1 m/s 188 km/h	**1,47** 48,5 m/s 175 km/h	**1,11** 42,2 m/s 152 km/h	**0,81** 36,0 m/s 130 km/h
20	**1,57** 50,1 m/s 180 km/h	**1,38** 46,9 m/s 169 km/h	**1,07** 41,4 m/s 149 km/h	**0,78** 35,3 m/s 127 km/h	**1,80** 53,6 m/s 193 km/h	**1,58** 50,3 m/s 181 km/h	**1,23** 44,3 m/s 160 km/h	**0,92** 38,5 m/s 138 km/h
35	**1,75** 52,9 m/s 190 km/h	**1,57** 50,1 m/s 180 km/h	**1,27** 45,1 m/s 162 km/h	**0,97** 39,5 m/s 142 km/h	**2,01** 56,6 m/s 204 km/h	**1,80** 53,7 m/s 193 km/h	**1,46** 48,3 m/s 174 km/h	**1,16** 43,1 m/s 155 km/h
50	**1,87** 54,6 m/s 197 km/h	**1,70** 52,1 m/s 188 km/h	**1,41** 47,5 m/s 171 km/h	**1,11** 42,1 m/s 152 km/h	**2,14** 58,5 m/s 211 km/h	**1,95** 55,9 m/s 201 km/h	**1,62** 50,9 m/s 183 km/h	**1,32** 45,9 m/s 165 km/h
75	**2,01** 56,7 m/s 204 km/h	**1,85** 54,4 m/s 196 km/h	**1,57** 50,1 m/s 181 km/h	**1,27** 45,0 m/s 162 km/h	**2,30** 60,7 m/s 219 km/h	**2,13** 58,3 m/s 210 km/h	**1,80** 53,7 m/s 193 km/h	**1,51** 49,1 m/s 177 km/h
100	**2,11** 58,1 m/s 209 km/h	**1,96** 56,0 m/s 202 km/h	**1,69** 52,0 m/s 187 km/h	**1,39** 47,1 m/s 170 km/h	**2,42** 62,2 m/s 224 km/h	**2,25** 60,0 m/s 216 km/h	**1,94** 55,7 m/s 201 km/h	**1,65** 51,4 m/s 185 km/h
200	**2,36** 61,5 m/s 221 km/h	**2,24** 59,9 m/s 216 km/h	**2,00** 56,5 m/s 203 km/h	**1,69** 52,0 m/s 187 km/h	**2,71** 65,9 m/s 237 km/h	**2,58** 64,2 m/s 231 km/h	**2,29** 60,5 m/s 218 km/h	**2,01** 56,7 m/s 204 km/h

The table below shows when the peak wind speeds are significant, depending on terrain type or height above the ground level (these are only calculation values).

Safety elements, wooden boxes and other wooden structures on the site:
Please go through DIN 1052 “Design of timber structures – General rules and rules for buildings” and EN 13374 “Temporary edge protection systems – Products specification and test methods” or other standards that apply to your country.

Other topics for discussion during theoretical and practical training parts:

- principles of reading the assembly drawings (measuring method, information given on the drawing, list of materials) – needed materials: example of a assembly drawing on a big paper format,
- principles of User Manuals - needed materials: a timber beam system User Manual,
- information given: element catalogue, basic information, specific solutions,
- quality check in detail (workshops) - needed materials: measuring tape, assembly drawing with quality check table,
- main types of tools needed for assembly, use, cleaning and service of the formwork (workshops) - needed materials: basic tools or manufacturer catalogues,
- formwork exploitation (site working cycle, release agent, cleaning), examples of materials (show samples) - needed materials: samples,
- the accuracy of assembly (main faults and impact on the concrete surface),

Information given:

- steel wailers on different heights – problems with joining the elements (not possible to join the wailers together),
- element e.g. not rectangular – problems with joining the elements, free space between plywood sheets, concrete flowing out,
- face of the panel not flat (wrong plywood assembly, plywood faults or damage) – wrong effect on concrete surface,

- carpenter and the panel formwork (wooden inserts, boxes and simple platforms) - needed materials: example pictures or drawings,
- carpenter on a slab formwork (cutting the plywood to the size) - needed materials: example pictures or drawings,
- European safety standards on building sites in Your country,

– weather and concrete effect on the condition of the wood - needed materials: example pictures.

Information given:

- Swelling, breaking and deflection of wood due to heat, sun and moisture on the site.

Part II – practical exercises

(2days)

These are proposals for workshop topics. Most of them involve using system parts from formwork companies and should be supervised by an experienced foreman, carpenter or a formwork specialist.

Exercise for the first group:
Prepare an assembly bench for next groups - needed materials: wooden boards cut to size, nails, tools.

Later exercises:
Assembly of a straight panel – needed materials: System elements (timber beams, steel wailers, plywood, connection accessories), tools, screw material.

Panel construction:
Prepare working area:

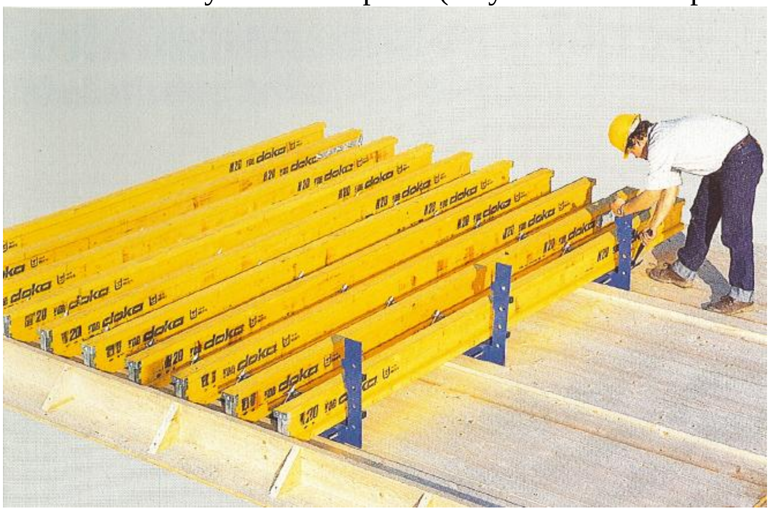
– find a place big enough for an assembly bench. Most of the times it will be bigger than the actual element you are assembling. There has to be place for You to move around and a dedicated place to cut elements to size nearby (electrical socket for circular saw and drilling machine etc.). If the participants are beginners leave the cutting to an experienced carpenter,
– gather all the tools, accessories and material You will need in a near and accessible place. Most of the elements You will carry by hand. Tools examples: measuring tape, hammer, electrical screwdriver, marker cord, carpenter pencil,
– put together an assembly bench according to panel design requirements,
– panel assembly.

The assembly:
Lay down the steel profiles on the assembly bench.

Lay down the H20 beams.

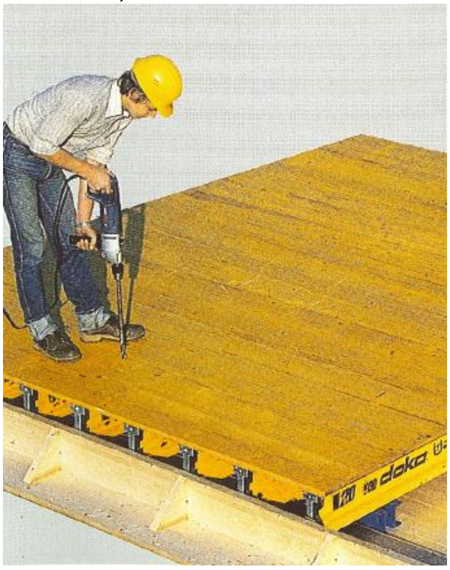
Connect the elements and accessories.

Put the assembly corners in place (they are needed to position the plywood correctly).



Place the plywood and screw it in.

NOTE: to assemble the plywood from the back You need to turn the element.
Drill the tie-rod holes (they must go through the ply and the middle of the steel wailer not damaging the beam).



Repeat the process 4-9 for the next element.

The afterwork
After finishing the assembly, clean the working area.

Assembly of a working platform.
Needed materials: System elements (timber beams, steel wailers, planks, connection accessories), tools, screw material. Similar order as with the straight panel.

Field trip (optional):
It is the best way to gather experiences as long as You will find a suitable place to show the presented solutions. For information about possible places to visit contact one of the local formwork or building companies for organizational help.

Test part

1. a) b) c) d)	What are the basic materials used in modern formworks? Timber boards, timber logs, nails. Timber beams, plywood, steel profiles. Steel frames, multilayer plywood, wooden inserts. Glass or carbon fibers, wooden frames.
2. a) b) c) d)	Where is the highest building built with the use of timber formworks? Empire State Building, New York, USA. Burj Khalifa, Dubai, UAE. Lomonosov Institute, Moscow, Russia. Woolloomooloo Bay Wharf, Sydney, Australia.
3. a) b) c) d)	When was the first use of system timber formworks? 18^{th} century, used to build the north wing of Versailles palace. 2560 BC, while building the Koufu pyramid. 1965, first used in Austria. 1980, with the use of first girder beam in Germany.
4. a) b) c) d)	How do You join plywood with beams? Screws, the plywood will not get loose when formwork is used. Ordinary wood glue, it is easier to correct assembly failures. Nails, it is faster and therefore the labour is cheaper. Epoxide resin, it is hard to destroy an element.
5. a) b) c) d)	How to check if an element is rectangular? Simply by looking at the element. By comparing the lengths of element’s edges. By comparing the lengths of element’s diagonals. There’s no need to do it.
6. a) b) c) d)	What does the SCC stand for? Stacking Corner Clamp. Self Compacting Concrete. Swedish Construction Council. Self Climbing Console.
7. a)	What are the criteria for choosing a formwork system? Price of the formwork.

b) c) d)	Is the formwork fireproof. Aesthetic value of the formwork. Technology restrictions.
8. a) b) c) d)	How big timber beam formworks can be put together ? 9,0m^2 72,0m^2 120,0m^2 As big as You can imagine
9. a) b) c) d)	Materials used in panel formworks: Steel frame. Wooden frame. Steel panel. Plywood panel.
10. a) b) c) d)	The curved shape of timber panels is: Achieved by the use of shaping woods. Achieved by treating the plywood with steam. Achieved by bending the steel profiles. Not possible to achieve.
11. a) b) c) d)	What is a composite? An alternative word for composition in musical terms. An internet site about computers. A material made from two or more other materials. An American competition for site managers.
12. a) b) c) d)	What do You need the assembly bench for? To sit when assembling the panel. As a base for assembling few equal panels in a row. As a measure for putting all elements together according to plan. As a place to lay the plan on.
13. a) b) c) d)	Where do they have the most restrictive safety laws: Luxemburg. Italy. Germany. France.

14. a) b) c) d)	Why You should use screws for attaching the plywood instead of nails: They are cheaper. It’s easier to mount them than nails. It’s not allowed to use nails because of problems with changing of the ply. The ply doesn’t go off of the panel while formwork striping.
15. a) b) c) d)	With what means climbing systems are climbed: Moved by the workers manually with ratchets. By crane. Are taken apart and put together in the next casting step. With hydraulic units.
16. a) b) c) d)	What is the carpenters job on modern sites: Pouring the concrete. Putting the formwork panels together. Making of the safety barriers, roofings, platforms and coverings. Carpenters don’t have anything to do on a site nowadays.
17. a) b) c) d)	What materials are most commonly used for safety barriers on sites? Wooden boards with a thickness of min. 2cm. Steel meshes. Plastic meshes. Steel scaffold tubes.

Chapter V PLUMBER PROFESSION

Presentation of solar thermal – method: lecture with multimedia presentation

Part 1 – theoretical lecture

Job description

The plumber performs tasks including the design, installation and testing of gas and water pipelines, sanitary systems, solar collectors, heat pumps, pools and air conditioning systems. He/she designs and installs heating systems, exhaust fume purification systems, and ventilation and combustion systems. He/she installs gas and diesel fuelled boilers, faucets and drainage systems. He/she understands the design of heating and water systems, the resistance of materials used and fluid machines and their mechanical characteristics.

There are three innovative areas of interest for the profession:

a) performing services that improve system performance,
b) installing systems that produce energy from renewable sources,
c) performing routine and extraordinary maintenance.

The training of plumbers is very important for those who take their profession seriously. Gaining competencies and knowledge in innovative areas can be a competitive advantage and allow the provision of better service to customers. A qualified plumber should provide services which are tailored to the customers' specific requirements, and also be able to inform customers of the costs and advantages of renovating buildings to increase energy efficiency. The plumber should inform the customer of the potential energy savings and any tax incentives.

A plumber should know about all aspects of energy efficiency, in particular. the legislative framework: for example, the national minimum standards for the energy performance of new buildings and existing buildings subject to major renovation; opportunities provided by national tax incentives, etc.

These new regulations and solutions to improve the efficiency and effectiveness of technologies already on the market, and the proposal of innovative technologies, encourage the plumber and other professions to continuously learn with a view to lifelong learning.

Plumber's tasks

The plumber is able to:

1. Design and plan the activities to be performed according to information acquired (schemes, designs, procedures, materials, etc.).
2. Arrange tools, equipment and engines appropriate for different working phases according to the activities to be performed, the procedures planned and the expected results.
3. Monitor equipment, tool and engine, functioning and perform ordinary maintenance.
4. Arrange and organize the workplace to comply with health and safety regulations, to prevent fatigue and industrial diseases.
5. Assemble systems.
6. Test systems in compliance with safety and efficiency standards.

7. Carry out ordinary and extraordinary maintenance in order to issue safe functioning documentation.

Theoretical training – first day – "Principles and technologies of solar thermal systems"

Climate changes

Climate change is one of the most important issues on a national and international scale. The Kyoto Protocol is a protocol aimed at fighting global warming. Under the Protocol, 37 industrialized countries (called "Annex I countries") are committed to a reduction of four greenhouse gases (GHG) (carbon dioxide, methane, nitrous oxide, sulphur hexafluoride) and two groups of gases (hydrofluorocarbons and perfluorocarbons), and all member countries give general commitments. Annex I countries agreed to reduce their collective greenhouse gas emissions by 5.2% from the 1990 level.

Kyoto Protocol and the European Union: the EU and its Member States ratified the Protocol in May 2002; the treaty was brought into force, effective 16 February 2005, after a required lapse of 90 days.

Under the Protocol, Annex I countries have committed themselves to national or joint reduction targets; a joint reduction of 8% for the European Union where each Member State has a specific target. Italy has committed to reduce its gas emissions by 6.5%.

How is it possible to achieve this goal?

- Reduction of consumption
- Use of renewable energy

Renewable energy

- Solar energy

Solar energy represents a source of clean, renewable and free energy, but the Earth is not equally radiated; solar energy can be harnessed in different amounts around the world, depending on geographical location. The closer to the equator the more "potential" solar energy is available.

- Wind energy

Since the 1970s, research into the generation of electricity using wind power has improved, alongside improvements in technology. Such energy has three characteristics: it is clean, renewable and the raw material is free!

- Water power

The force or energy of moving water could provide 6.7% of global energy demand and 20% of the consumed energy. The "Third World" uses this clean and cheap resource which unfortunately has a questionable environmental impact.

- Geothermal power

The Earth's temperature increases approximately 1 degree with every 30 meters of depth. Currently , across the globe about 130 plants use water vapour rising from the subsoil to produce energy.

- Biomass

Wood is the most important biomass fuel. Wood energy is derived both from direct use of harvested wood as a fuel and from wood waste streams. In the Southern Hemisphere about 80% of the population use it to produce energy. Biomass represents a renewable and inexhaustible resource if it is used without biological renewal. Other constraints are the range of cultivated land and the climate constraints that affect the development of different forests.

Biomass energy is derived from different energy sources:

- forests and woods
- different types of plants
- waste
- industrial waste

Reduction of consumption

- Ministerial Decree – 20/07/2004

New policy to promote energy saving by introducing an innovative system at international level

- White certificates: issued by the authority managing the energy market to organizations and bodies which have achieved fixed standards of energy saving
- Green certificates: yearly certificates awarded by the Body managing electrical services; they confirm the production of 50 Megawatts of energy by renewable sources

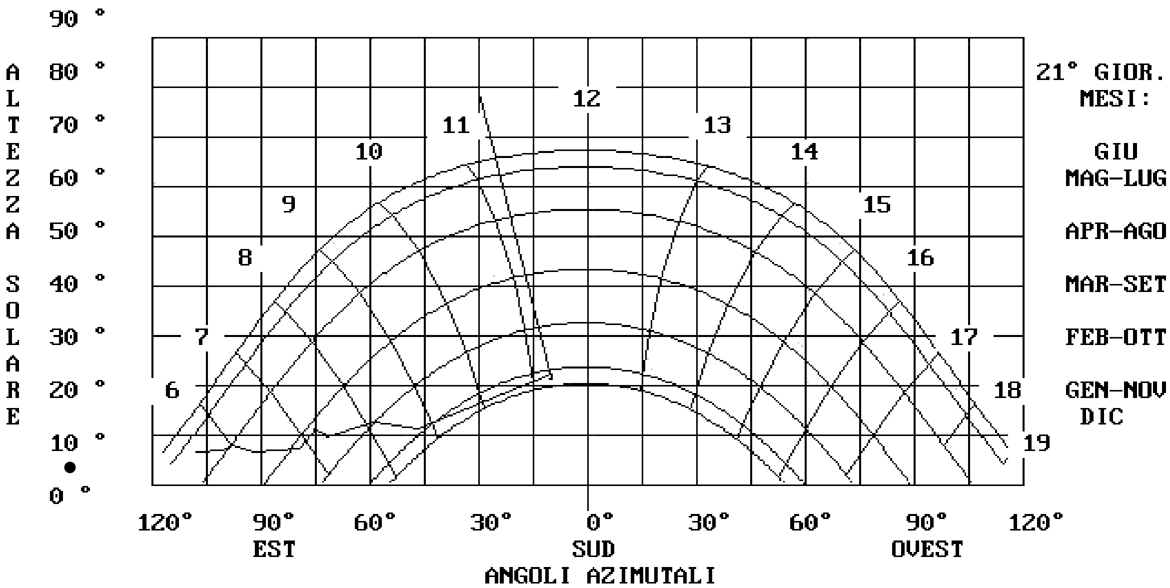
The sun

The solar constant is the amount of incoming solar electromagnetic radiation per unit area that would be incident on a plane perpendicular to the rays, at a distance of one astronomical unit (AU) (roughly the mean distance from the Sun to the Earth):

Solar constant = 1367 W/m²

- Solar diagrams

They are used to calculate radiation according to the latitude and the different months.



- Solar radiation

Direct radiation + Indirect radiation + Albedo = Total radiation

- Uses of thermal solar energy:

– heating sanitary water,
– environment heating,
– heating pools,
– heating greenhouses,
– drying out agricultural products,
– purifying sea water,
– producing energy,
– producing hydrogen,
– air-conditioning.

Passive and active systems

Passive systems are those such as greenhouses and the Trombe Wall.

Active systems are solar collectors, etc.

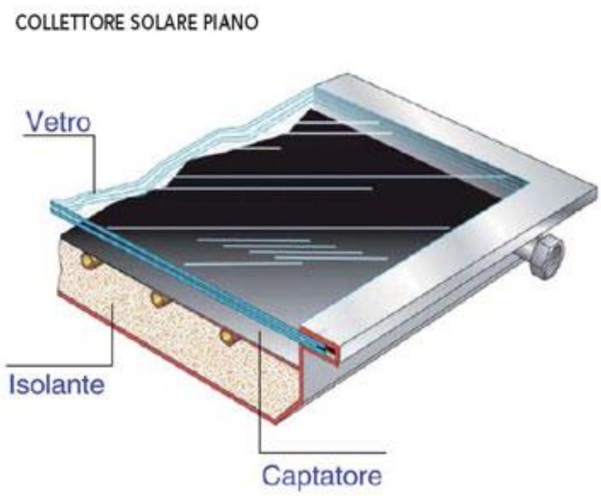
Passive systems do not employ mechanical engines to transport fluids. They are based on spatial interaction between the radiant energy and the energy provided to the internal spaces.

Active systems are divided into:

- flat plate collectors
- evacuated tube collectors.

Flat plate collectors

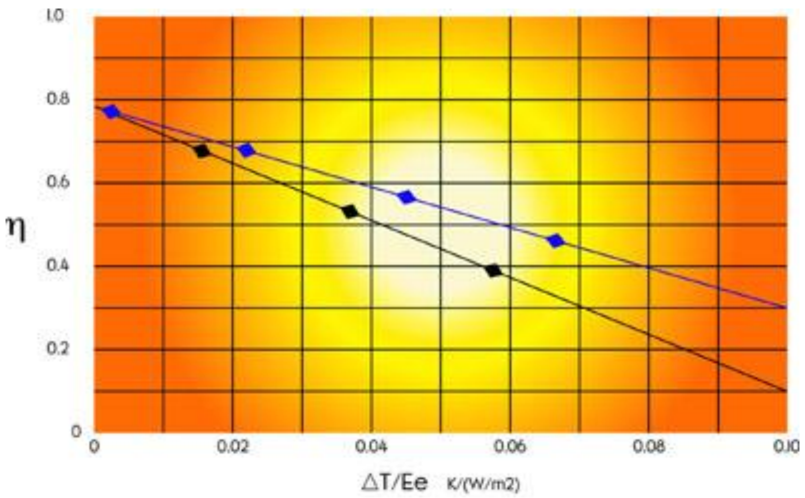
The absorber consists of a thin absorber sheet (of thermally stable polymers, aluminium, steel or copper, to which a black or selective coating is applied) backed by a grid or coil of fluid tubing placed in an insulated casing with a glass or polycarbonate cover.



Performance of the flat plate collector

Discussion and remarks on the difference of dispersion between aluminium copper with a black coating and stainless steel copper.

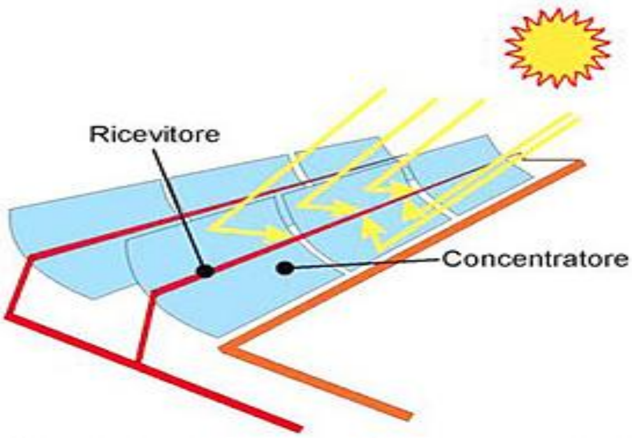
The following diagram shows that the second case provides less energy dispersion.



Parabolic through

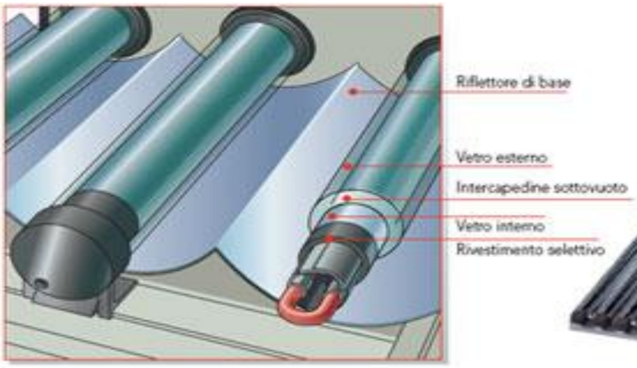
The collector is based on a parabolic dish which collects and concentrates the sunlight on an absorber tube which absorbs sunlight and transfers it to a solar field piping

Evacuated tube collectors



Evacuated tube collectors have multiple evacuated borosilicate glass tubes which heat up solar absorbers and, ultimately, solar working fluid (water or an antifreeze mix—typically propylene glycol) in order to heat domestic hot water or for hydronic space heating.

Their performance is high and consistent throughout the year and they are fitted to areas with a medium-low exposure to sunlight, or where climate conditions are wintry.



Storage tank

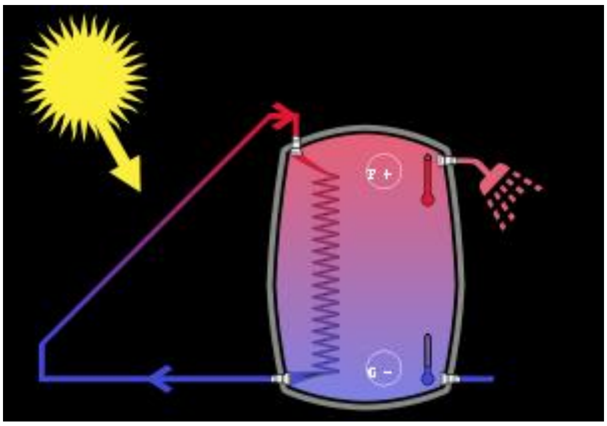
They are functional for storage of hot sanitary water and are made of carbon steel or stainless steel 316 L; they come in a range of sizes and capacity from 200 to 5000 litres. They are caulked and have specific devices to connect to the pipes.

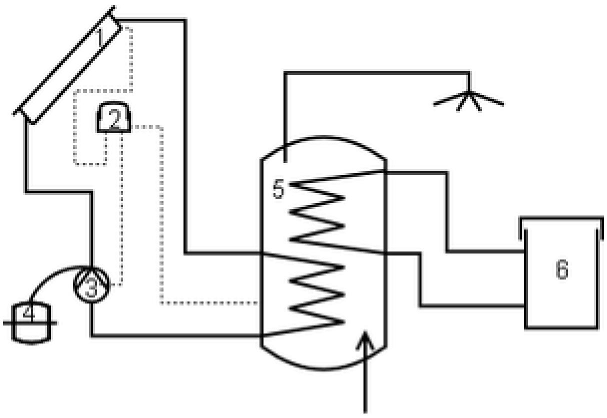
Classification of solar systems

Solar systems can be classified into

- direct
- indirect

Brief explanation and relative figures





Comparison between the two types of systems: list of benefits and disadvantages

<u>System components and examples of systems</u>

- Heating system – sanitary water
- Heating system
- Integrated system
- System with heat pump
- System with absorption machine

Components:

- Insulated pipes
- Control valves
- Thermostats
- Expansion tank
- Junction box

<u>Charging the solar circuit</u>

A professional pump is used to charge the solar system with propylene glycol. The circuit pressure should be 1.5 bar; the charge of the low part of the system.

2. Theoretical training – second day – "Solar thermal systems"

<u>Installation and maintenance of system components</u>

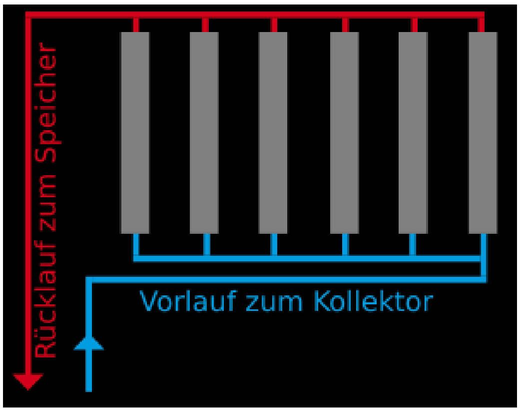
<u>Placing the solar collectors</u>

The solar energy quantity which bears on a plane depends on

A. the plane inclination (Tilt)
B. the orientation (Azimuth)

In order to be efficient the system should be placed between South East and South West.

The best inclination to produce a maximum quantity is equal to latitude (35-45°): + 10° in winter and -10° in summer.



<u>Tichelmann system</u>

The maximum capacity of a solar collector should not be over 110 litres/hour for each m² (limit) and less than 50 litres/hour for each m².

There should not be more than 6 collectors.

<u>Heating pools</u>

It is preferable to use a titanium heat exchanger to prevent possible corrosion.

If the pool is used only during a specific period (eg. April – October) the surface exposed to sunlight should not be bigger than the minimum surface which supplies the whole demand in the hottest month through the sun.

<u>Maintenance</u>

- During the first two years check the circuit pressure (glycol density). In case of a leak it is necessary to check the glycol acidity (around Ph7)
- After 5 years it is necessary to replace the magnesium anode and clean up any limestone in the storage tank (by pressure washing or where possible hand-wash).

Calculation method

Solar thermal calculation

A. Daily consumption of sanitary water
B. Daily demand to heat the rooms
C. Daily heat provided by the collector
D. Choice of the number of collectors
E. Produced and used heat

Energy provided by the system

Description of the formulas and explanation of the tables

Practical rules

One example: Northern Italy

Economic analysis

Economic value

Is based on the following factors:

- Economic value of the used heat
- System cost
- Investment profit

Cost items

One example: direct system

- System components: 40%
- Distribution: 25%
- Installation: 30%
- Design: 5%
- Cost per square meter: 600-800 €/ m²
- Minimum cost: € 4.000,00

Profit and choice of the reflecting surface

Analysis of the formula to calculate it and examples of economic analysis

Law and regulations

- Act 10/91
- Legislative decree No. 192 – 19/08/2005

- Procedures to get the authorizations

National tax incentives

Description and analysis of possibilities

Examples

3. Theoretical training – third day – “Solar cooling”

Absorption principle

Solar cooling

Absorption systems are powered by heat at low temperature:

- Scrap heat
- Solar energy

The fluids are neither toxic nor dangerous. They work without engines; they don’t use electricity and they represent a good solution to the Kyoto Protocol requirements. They have also have low noise impact.

Principles

The absorption cycle has three features which are common to one based on mechanical compression:

- the condenser
- the valve
- the evaporator.

It is different in that it employs a different way to transfer the energy to the refrigerant. In the absorption machine there are cycles of two fluids:

- refrigerant
- absorption liquid.

The two cycles can cross since the refrigerant is dissolved in the other liquid (in some parts of the circuit); in other parts it is separated and sometimes it is independent.

The absorption cycles are divided into two types:

- high-pressure – the condenser and the device to delete the possible contaminations
- low-pressure – the evaporator and the absorber

How the system works

Brief explanation and relative figures

Absorption groups

Description of the scheme and the relating equation

Types of systems

Description of the different types and their performances

Examples of systems in Europe and Italy

4. Conclusions

The students will answer questions relevant to the theoretical part:

- What are the principles of solar thermal technologies?
- What are the benefits and advantages in using this innovative technology?
- What is innovative about this method and system?
- What are the benefits for the environment and energy saving?

Theoretical training will be carried out using a multimedia presentation (DVD) containing explanations, figures and tables

Discussion

Part II – practical exercises
(2 days)

Two days

The trainer will show and explain the procedure to install a solar thermal system to get a hot water system according to a specific manual.

Then he/she will give one copy of the manual to each student.

The installation of the solar thermal system will be carried out on the ground since it is impossible to install it on a roof in a teaching environment. It will take two days.

Required tools and devices
The Kit includes solar thermal collectors and the boiler as well as all necessary parts for installing and testing the solar thermal system:
Heat Pipe vacuum-packed solar thermal collectors with the support structure for use on the ground
Control and regulation devices: the pump, flow measurer, manometer, the check valve, the safety valve and the connection for the expansion tank
Storage tank with 1 or 2 heat exchangers made of copper

Expansion tank and related joints
Set of joints, air and safety valves, temperature drill
Solar junction box with microprocessor for system management
Propylene glycol for the solar circuits

<u>Practical installation procedure</u>

The students will be divided into 3 groups. Each group will perform specific tasks related to each installation phase.

1 group: Installation of the solar station and of the boiler
2 group: Installation of the junction box and the pumps
3 group: installation of the solar thermal collectors and connection

In the final part the 3 groups will work together to carry out the procedures required to make the system functional

The trainer will check each group to control the work and make suggestions or correct wrong procedures. Based on the work, the trainer will give a score to each group.

Discussion, exchange of experiences, FAQs, remarks and conclusions.

Test part

1. The sun: the power which bears on a orthogonal surface to the sunlight and out of the atmosphere is:
    a) <u>ICS = 1367 W/m²</u>
    b) ICS = 867 W/m²

2. Solar diagrams
    a) <u>They are used to calculate radiant light according to the latitude and the different months of the year</u>
    b) They are used to calculate the radiant light according to the Azimuth and the different months of the year

3. The total radiant light is the sum of the factors: DIRECT RADIANT LIGHT + INDIRECT RADIANT LIGHT + ??????
    a) <u>Albedo</u>
    b) Absorbed radiant light

4. Flat plate solar thermal collectors: which component captures solar energy and transfers it to the tubes of the collectors?
    a) <u>The sheet</u>
    b) The transparent cover

5. The performance of a flat plate collector depends on:
    a) <u>the temperature difference between the fluid and the environment</u>
    b) the temperature difference between the collector and the environment

6. Evacuated tube collectors: they have a high performance year-round and they are appropriate for installation in areas with a
    a) medium-high insolation
    b) <u>medium-low insolation</u>

7. Storage tank: to optimise water stratification what is the ratio of storage sizes?
    a) <u>$H/D \geq 1.5$</u>
    b) $H/D \geq 2.5$

8. Placement of solar thermal collectors

Azimuth: in order to be efficient the collector should be located at
    a) <u>South-East</u>
    b) South-West

9. Tilt – Milan: the best inclination of the collectors in order to get maximum production is
   a) 55°
   b) 35°

10. Tichelmann system: the minimum capacity in solar thermal collectors should not be less than…….litres/hour for one square meter
    a) 150 litres/hour
    b) 50 litres/hour

11. Demand of hot sanitary water: daily consumption for 1 person
    a) 80 litres/person
    b) 300 litres/person

12. Practical rules: Northern Italy
    a) 1 m² of evacuated tube collector = 2 m² of flat plate collectors
    b) 1 m² of evacuated tube collector = 1 m² of flat plate collectors

13. Practical rules: size of expansion tank for 1 m² of collector
    a) 6 litres
    b) 10 litres

14. The total cost of a solar thermal system is
    a) cost per 1 m² = 500 €/m²
    b) cost per 1 m² = 800 €/m²

15. In order to work the heat absorption pump uses:
    a) high temperature heat
    b) low temperature heat

16. Which fluid is used by a heat pump?
    a) Gas water
    b) Water – glycol

Chapter VI ELECTRICIAN PROFESSION

Part 1 – theoretical lecture

Job description

Electricians install and maintain all the electrical and power systems for homes, businesses, and factories. They install and maintain the wiring and controlling equipment through which electricity flows. They also install and maintain electrical equipment and machines in factories and a wide range of other businesses.

Electricians generally focus on either construction or maintenance, although many do both. Electricians specialized on constructions primarily install wiring systems into factories, businesses, and new homes. Electricians specialized on maintenance fix and upgrade existing electrical systems and repair electrical equipment. All electricians must follow State and local building codes and the National Electrical Code when performing their work.

Electricians usually start their work by reading blueprints— technical diagrams showing the locations of circuits, outlets, load centers, panel boards, and other equipment. After determining where all the wires and components will go,the electricians install and connect the wires to circuit breakers, transformers, outlets, or other components and systems.

When installing and wiring, electricians use handtools such as conduit benders, screwdrivers, pliers, knives, hacksaws, and wire strippers, as well as power tools such as drills and saws. Later, they use ammeters, ohmmeters, voltmeters, harmonics testers, and other equipment to test connections and ensure the compatibility and safety of components.

Maintenance electricians repair or replace electric and electronic equipment when they are damaged. They make needed repairs as quickly as possible in order to minimize inconvenience. They may replace items such as circuit breakers, fuses, switches, electrical and electronic components, or wires.

Electricians also periodically inspect all equipment to ensure the proper operation and to correct problems before breakdowns occur.

Maintenance work varies greatly, depending on where an electrician works. Electricians who focus on residential work, perform a wide variety of electrical work for homeowners. They may rewire a home and replace an old fuse box with a new circuit breaker box to accommodate additional appliances, or they may install new lighting and other electric household items, such as ceiling fans. These electricians also might do some construction and installation work.

Electricians in large factories usually do maintenance work that is more complex. These kinds of electricians may repair motors, transformers, generators, and electronic controllers on machine tools and industrial robots. They also advise management as to whether the continued operation of certain equipment could be hazardous. When working with complex electronic devices, they may consult with engineers, engineering technicians, line installers and repairers, or industrial machinery mechanics and maintenance workers.

Work environment.

Electricians work indoors and out, at construction sites, in homes, and in businesses or factories. The work may be strenuous at times and may include bending conduit, lifting heavy objects, and standing, stooping, and kneeling for long periods. Electricians risk injury from electrical shock, falls, and cuts, and must follow strict safety procedures to avoid injuries. Data show that full-time electricians experienced a work-related injury and illness rate that was higher than the average.

When working outdoors, they may be subject to inclement weather. Some electricians may have to travel long distances to jobsites.

Tasks and Duties

- Assemble, install, test, and maintain electrical or electronic wiring, equipment, appliances, apparatus, and fixtures, using hand tools and power tools.
- Diagnose malfunctioning systems, apparatus, and components, using test equipment and hand tools, to locate the cause of a breakdown and correct the problem.
- Connect wires to circuit breakers, transformers, or other components.
- Inspect electrical systems, equipment, and components to identify hazards, defects, and the need for adjustment or repair, and to ensure compliance with codes.
- Advise management on whether continued operation of equipment could be hazardous.
- Test electrical systems and continuity of circuits in electrical wiring, equipment, and fixtures, using testing devices such as ohmmeters, voltmeters, and oscilloscopes, to ensure compatibility and safety of system.
- Maintain current electrician's license or identification card to meet governmental regulations.
- Plan layout and installation of electrical wiring, equipment and fixtures, based on job specifications and local codes.
- Direct and train workers to install, maintain, or repair electrical wiring, equipment, and fixtures.
- Prepare sketches or follow blueprints to determine the location of wiring and equipment and to ensure conformance to building and safety codes.
- Use a variety of tools and equipment such as power construction equipment, measuring devices, power tools, and testing equipment including oscilloscopes, ammeters, and test lamps.
- Install ground leads and connect power cables to equipment, such as motors.
- Perform business management duties such as maintaining records and files, preparing reports and ordering supplies and equipment.
- Repair or replace wiring, equipment, and fixtures, using hand tools and power tools.
- Work from ladders, scaffolds, and roofs to install, maintain or repair electrical wiring, equipment, and fixtures.
- Place conduit (pipes or tubing) inside designated partitions, walls, or other concealed areas, and pull insulated wires or cables through the conduit to complete circuits between boxes.
- Construct and fabricate parts, using hand tools and specifications.
- Fasten small metal or plastic boxes to walls to house electrical switches or outlets.
- Perform physically demanding tasks, such as digging trenches to lay conduit and moving and lifting heavy objects.
- Provide preliminary sketches and cost estimates for materials and services.
- Provide assistance during emergencies by operating floodlights and generators, placing flares, and driving needed vehicles.

Theoretical training – first day – “Solar Basics”

Climate changes

Climate change increasingly accepted as one of the biggest man-made threats facing our globe if we continue to burn fossil fuels as of today. We have now reached a point, where CO2- and other green house gas emissions have already induced excessive floods, draughts and intensified hurricanes and typhoons. If we are not rigorously changing our fossil fuel addiction we very soon are crossing a point, when not even more floods, droughts and heavier storms are occurring but changes in ocean circulation, melting of glaciers and even the artic ice will occur with obviously destructive results for mankind. Fortunately, we have technologies at hand – the portfolio of Renewable Energies – that could change this death spiral towards a green and sustainable well being. Reports are a useful guide, but it is people who change the world by their actions. We encourage politicians and policymakers, global citizens, energy officials, companies, investors and other interested parties to support solar power by taking the crucial steps to help ensure that more than a billion people will get electricity from the sun in the future, harnessing the full potential of solar power for our common good.

What is photovoltaic energy

“Photovoltaic” is a marriage of two words: “photo”, meaning light, and “voltaic”, meaning electricity. Photovoltaic technology, the scientific term used to describe what we use to convert solar energy into electricity, generates electricity from light.

We use a semi-conductor material which can be adapted to release electrons, the negatively charged particles that form the basis of electricity. The most common semi-conductor material used in photovoltaic (PV) cells is silicon, an element most commonly found in sand.

All PV cells have at least two layers of such semi-conductors, one positively charged and one negatively charged. When light shines on the semi-conductor, the electric field across the junction between these two layers causes electricity to flow, generating DC current. The greater the intensity of the light, the greater the flow of electricity.

A photovoltaic system therefore does not need bright sunlight in order to operate. It also generates electricity on cloudy days by a rationing of the energy output that depends on the density of the clouds. Due to the reflection of sunlight, days with slight cloud can even result in higher energy yields than days with a completely cloudless sky.

Generating energy through solar PV is quite different from how a solar thermal system works, where the sun’s rays are used to generate heat, usually for hot water in a house, swimming pool etc.

THE ADVANTAGES OF SOLAR POWER:

- The fuel is free.
- There are no moving parts to wear out, break down or replace.
- Only minimal maintenance is required to keep the system running.
- The systems are modular and can be quickly installed anywhere.
- It produces no noise, harmful emissions or polluting gases.

PV Technology

The most important parts of a PV system are the CELLS which form the basic building blocks of the unit which collects the sun’s light, the MODULES which bring together large numbers of cells into a unit, and, in some situations, the INVERTERS used to convert the electricity generated into a form suitable for everyday use.

- PV CELLS AND MODULES
- CRYSTALLINE SILICON
- THIN FILM
- OTHER CELL TYPES
- CONCENTRATOR CELLS
- SPHERAL SOLAR TECHNOLOGY

Types of PV systems

- GRID CONNECTED
- OFF-GRID
- HYBRID SYSTEM
- GRID-CONNECTED SYSTEMS:

The benefits of solar power

Photovoltaic power systems offer many unique benefits above and beyond simple energy delivery. That is why comparisons with conventional electricity generation - and more particularly comparison with the unit energy costs of conventional generation - are not always valid. If the amenity value of the energy service that PV provides, or other non-energy benefits, could be appropriately priced, the overall economics of PV generation would be dramatically improved in numerous applications, even in some grid-connection situations.

Space – saving installation

PV is a simple, low-risk technology that can be installed virtually anywhere where there is available light. This means that there is a huge potential for the use of roofs or façades on public, private industrial buildings. PV modules can be used as part of a building's envelope, providing protection from wind and rain or serving to shade the interior. During their operation such systems can also help reduce buildings' heating loads or assist in ventilation through convection.

OTHER PLACES WHERE PV CAN BE INSTALLED include the sound barriers along communication links such as motorways. Also areas such as former mining land are suitable for large ground based PV systems. Improving the electricity network

For power companies and their customers, PV has the advantage of providing relatively quick and modular deployment. This can offset investment in major new plant and help to strengthen the electricity network, particularly at the end of the distribution line. Since power is generated close to the point of use, such distributed generators can reduce transmission losses, improve service reliability for customers and help to provide peak power demand.

Protecting the environment

Solar power involves none of the polluting emissions or environmental safety concerns associated with conventional generation technologies. There is no pollution in the form of exhaust fumes or noise during operation. Decommissioning a system is unproblematic.

Most importantly, in terms of the wider environment, there are no emissions of carbon dioxide - the main gas responsible for global climate change (see Climate Change and Fuel Choices) during the operation of a PV system. Although indirect emissions of COc occur at other stages of the life-cycle, these are significantly lower than the avoided emissions. Solar power can therefore make a

substantial contribution towards international commitments to reduce emissions of greenhouse gases and their contribution to climate change (see box The Climate Change Imperative), if governments adopt a wider use of PV in their national energy generation.

Theoretical training – “PV System Installation”

Necessary Equipment for the class

1. A P.C. with DSL internet connection and office software (including PowerPoint)
2. A projector with screen
3. Pictures and Drawings of photovoltaic modules and equipment
4. Brochures, assembling and installation Instructions
5. A page with the basic Calculating Formulas for every trainee

Basic Principles to Follow When Designing a Quality PV System

1. Select a packaged system that meets the owner's needs. Customer criteria for a system may include reduction in monthly electricity bill, environmental benefits, desire for backup power, initial budget constraints, etc. Size and orient the PV array to provide the expected electrical power and energy.
2. Ensure the roof area or other installation site is capable of handling the desired system size.
3. Specify sunlight and weather resistant materials for all outdoor equipment.
4. Locate the array to minimize shading from foliage, vent pipes, and adjacent structures.
5. Design the system in compliance with all applicable building and electrical codes.
6. Design the system with a minimum of electrical losses due to wiring, fuses, switches, and inverters.
7. Properly house and manage the battery system, should batteries be required.
8. Ensure the design meets local utility interconnection requirements.

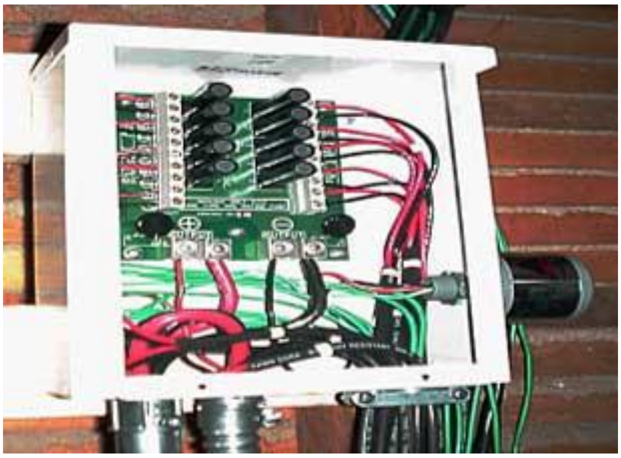
Basic Steps to Follow When Installing a PV System

1. Ensure the roof area or other installation site is capable of handling the desired system size.
2. If roof mounted, verify that the roof is capable of handling additional weight of PV system. Augment roof structure as necessary.
3. Properly seal any roof penetrations with roofing industry approved sealing methods.
4. Install equipment according to manufacturers specifications, using installation requirements and procedures from the manufacturers' specifications.
5. Properly ground the system parts to reduce the threat of shock hazards and induced surges.
6. Check for proper PV system operation by following the checkout procedures on the PV System Installation Checklist.
7. Ensure the design meets local utility interconnection requirements
8. Have final inspections completed by the Authority Having Jurisdiction (AHJ) and the utility (if required).

Specific Installation procedures

- install of the mounting system
- assembling the modules and form sub-arrays, attach the ground wires at the frames
- lift the sub – arrays to the roof

- Placing the sub arrays at the mounting system
- Junction box(es), combiner box(es)



- Inverters

- AC, DC wiring, gounding of the inverter

- Connection to the building’s electric panel
- Batteries
- Connection with the existing AC grounding system

Safety

1. General safety regulations.
2. Specific Safety Rules for the installation.
3. Personal protective equipment (PPE).

Theoretical training – “PV System Maintenance”

Maintenance Steps

Step 1: At the Inverter
Step 2: On the Roof

Rinse the PV array to remove debris.

Step 3: At the Combiner Box(es)
Step 4: Inside
Step 5: Back at the Inverter

System Troubleshooting

Troubleshooting a PV system usually means:

1. A load does not operate properly or not at all;
2. The inverter does not operate properly or not at all; or
3. The array has low or no voltage or current.

A qualified electrician should check and correct electrical problems in a PV system, since homeowners are unlikely to be qualified to perform such work.

Conclusions

The students will answer to questions regarding the theoretical part about:

- The principles of the pv technologies?
- The benefits and advantages in using this innovative technology?
- The benefits for the environment and the energy saving?
- The basic calculation formulas,
- The safety rules and regulations,
- The necessary tools and equipment,
- How we plan the Installation procedure,
- A short briefing of the installation procedures (Every trainee answer a different part of the procedures),
- Problems may occur and solutions for them maintenance Procedures (Every trainee answer a different part of the procedures).

Discussion

Part II – practical exercises

Organizing the practical part

The trainer will show and explain according to a specific manual the procedure to install a PV system.

Then he/she will deliver one copy of the manual to each student.

The installation of the pv system will be carried out on the ground since it is impossible to install it on a roof. It will take two days.

Required tools and devices

Hand and Power Tools

Workers using hand and power tools may be exposed to a number of hazards, including objects that fall, fly, are abrasive, or splash; harmful dusts, fumes, mists, vapors, and gases; and frayed or damaged electrical cords, hazardous connections and improper grounding. Hazards are usually caused by misuse and improper maintenance. Basic tool safety rules include regular maintenance, using the right tool for the job, pre-use inspections, following manufacturers' instructions and using the proper personal protective equipment (PPE) such as hand, eye, breathing and hearing protection. Power tools must be fitted with guards and safety switches. Requirements and hazards associated with power tools varies depending on the power source, which includes electric, pneumatic, liquid fuel, hydraulic, powder-actuated equipment. Usually an electrician will have a personal set of hand tools and general-purpose test instruments, with the more costly power tools or instruments provided by the employer or business.

Some of the more common tools are:

- Pipe and tube Bender,
- Lineman's pliers: Heavy-duty pliers for general use in cutting, bending, crimping and pulling wire,
- Diagonal pliers (also known as side cutters or Dikes): Pliers comprising of a cutting blades only for use on smaller gauge wires, but sometimes also used as a gripping tool for removal of nails and staples,
- Needle-nose pliers: Pliers with a long, tapered gripping nose of various size, with or without cutters, generally smaller and for finer work (including very small tools used in electronics wiring),
- Wire strippers: Plier-like tool available in many sizes and designs featuring special blades to cut and strip wire insulation while leaving the conductor wire intact and without nicks. Some wire strippers include cable strippers among their multiple functions, for removing the outer cable jacket,
- Cable cutters: Highly leveraged pliers for cutting larger cable,
- Rotosplit: A brand-name tool designed to assist in breaking the spiral jacket of metallic-jacketed cable (MC cable),
- Multimeter: A battery-powered instrument for electrical testing and troubleshooting; common features include the ability to measure and display voltage, resistance, and current with other types of measurements included depending on the make and model. Are available in digital or analogue,
- Step-bit: A metal-cutting drill bit with stepped-diameter cutting edges, generally at 1/8-inch intervals, for conveniently drilling holes to specification in stamped/rolled metal up to about 1/16" thick; for example, to create custom knock-outs in a breaker panel or junction box,
- Cord, rope and/or fish tape. Used to 'fish' cables and wires into and out of cavities. The fishing tool is pushed, dropped, or shot into the installed raceway, stud-bay or joist-bay of a finished wall or in a floor or ceiling. Then the wire or cable is attached and pulled back,
- Crimping tools: Used to apply terminals or splices. These may be hand or hydraulic powered. Some hand tools have ratchets to insure proper pressure. Hydraulic units achieve cold welding, even for aluminum "locomotive" [many fine strands] cable,
- Insulation Resistance Tester: Commonly referred to as a Megger. Insulation testers apply several hundred to several thousand volts to cables and equipment to determine the insulation resistance value of the item being tested. Modern insulation resistance testers often have a ohm meter function available and are often included as a function of a multimeter,
- Knockout punch: For punching holes into sheet metal to run wires or conduit,
- Other general-use tools with applications in electric power wiring include screwdrivers, hammers, reciprocating saws, drywall saws, metal punches, flashlights, chisels, adjustable slip-joint pliers and drills,
- Test light,
- Ground Fault Indicator Tester,
- Pyranometers,
- Hydrometers,
- Thermometers,
- Voltmeters,
- Ammeters.

<u>Practical installation procedure</u>

The students will be divided into 3 groups. Each group will perform specific tasks pertaining to each installation phase.

- 1 group: Construction of the Mounting system, assemble the PV panels and form the Sub – arrays,
- 2 group: Installation of junction boxes, combiner boxes, Conduits and Wires from the PV panels to the inverter,
- 3 group: Grounding system, inverter, Conduits and wires from the Inverter to the Main panel.

In the final part the 3 groups will work together in order to perform all the procedures functional to put into operation the system.

The trainer will check each group in order to control the work and eventually make suggestions or correct the wrong procedures. According to the work the trainer will give a score to each group.

Discussion, exchange of experiences, FAQs, remarks and conclusions.

Test part

1. Give three ways that a PV cell and a battery alike.

Answer:

They both convert one form of energy into another, they both have a positive and a negative side, and they both produce direct current electricity.

2. A battery converts chemical energy into electrical energy. What type of energy does a PV cell convert?

Answer:

PV cells convert light energy into electrical energy.

3. Since each individual PV cell’s electrical output is small, how can the cells be configured to produce the electrical output needed to power a high electric demand?

Answer:

The PV cells can be connected in series/parallel strings to increase the voltage/current output of the resulting string. Each string can be connected in series/parallel to increase the electrical output to the level that will match the demand.

4. In most situations, why is an inverter needed for a PV system?

Answer:

Inverters change Direct Current into Alternating Current for powering appliances, tools, and other devices commonly found in the home.

5. What function does the combiner box perform in a PV system?

Answer:

The combiner box allows strings of modules to be safely connected in parallel thus producing one high amperage circuit to the inverter in a grid-connected situation or the charge controller in a remote installation.

6 During the initial site visit to check a single story building’s acceptability for a PV system, you note that the asphalt-shingled roof has a 4/12 slope and is oriented 10 degrees to the west of true south. The south-facing roof is a rectangle that is 30 feet wide and 20 feet from the eaves to the roof top. Is this building a good candidate for a PV installation? If it is and given that the roof can support the PV system and a 3-person installation crew, what would you suggest to the building owner as the largest, safe array (peak output) to install?

Answer: The roof would be a good candidate if it was shade-free from about 9 a.m. to 3 p.m. I would allow at least a foot of free roof around the array: 28 ft X 18 ft = 504 ft2 of area for the array. 504 X 12 = 6048 peak Watts max.

7 For the same building described in question 1, what conditions might you encounter that would make you reject the site for a system installation?

Answer: Tall trees, a chimney, or other shade sources, air vent pipes in the way, the shingles need to be replaced, local covenants prohibiting solar devices, or electrical system up to code.

8 What estimated cost would you tell the building owner for an installed PV system with a peak output of 3000 Watts?

Answer: 5-6 Euro's/Watt = 15,000 to 18,000 E to install the system.

9 Why is an inverter needed in a grid-connected PV installation?

PV modules produce dc electricity and the building's electrical appliances and equipment are designed to operate on AC electricity.

10 Why is an inverter needed in a remote or stand-alone PV system?

Answer: PV modules produce DC electricity which is stored in batteries, but most of the building's electrical appliances and equipment are designed to operate on ac electricity.

11 Given that the building owner wants to install a grid-connected PV system, how would you size the inverter?

Answer: I would determine the area available to install the PV array and work within the building owner's present budget and the future potential array size increase to determine the PV array's output. I'd use the array's peak output as the minimum size for the inverter.

12 What is the color of the grounded conductor in a PV installation and how is it sized?

Answer: The grounded conductor in a PV system is white and sized to safely carry the overcurrent device protecting the circuit.

13 What is the color of the equipment/frame ground wire in a PV installation and how is it sized?

Answer: The equipment and frame grounding wire can be green or bare copper and is sized to safely carry the largest load that could occur in the circuit.

14 What function does the equipment/frame ground perform?

Answer: The equipment ground prevents current flows that could injure/kill people or harm equipment.

15 Given that a PV system uses modules outputting a nominal 12 volts at 5 amperes, the modules are 10 m from a combiner box, and you can only tolerate a 2% voltage drop, what gauge of wire should be used to connect the modules with the combiner box? What gauge of wire if the modules strings were 24 volt at 5 amps?

Answer: [From the 3% voltage drop table -12 volt, 5 amp, 12 gauge wire for 8m or 13m in 10 gauge wire] for a 2% voltage drop, modifiy the table distances by 60 cm. Therefore, use 8- gauge wire in the 12-volt system. For the 24-volt system, you can safely use the 12-gauge wire to connect the modules and the combiner box.

16 Why is the equipment ground necessary between the modules and the inverter? Can the same reason be used for installing the equipment ground between the inverter and the electric panel?

Answer: The equipment ground is installed to prevent unwanted currents from flowing causing equipment damage, personal injury, or even death given the right conditions when a person comes in contact with the equipment's metal case.

17 Why is low-voltage power dangerous?

Answer: Low voltage causes the muscles to contract thereby it is possible that you can’t let go. At higher voltages you can let go, and if the voltage is high enough it will burn itself away.

18 Does a PV module with an open circuit voltage and amperage of 27 and 3.5 respectively under full sun conditions present a shock hazard for someone who comes in contact with the wires? Explain your answer.

Answer: This situation is a serious shock hazard for anyone coming in contact with the wires. The voltage is high enough to overcome the skins resistance and the amp level is such that death could occur depending on the path between the wire contacts.

19 What is the function of the combiner box?

Answer: The combiner box is a device that allows individual electrical strings to be connected in parallel. The amp value of each string is added to produce one output with the ampere equal to the amp sum of the inputs.

20 Why is there disconnect switch between the inverter and the PV array?

21 Why is there a disconnect switch between the inverter and the building’s electric panel?

Answer: To isolate the inverter from the utility, whenever the inverter is shutdown for repair of the inverter or any of the upstream portion of the PV system.

22 What are the two factors used to determine the size of wire to install in the PV system?

Answer: The current flow in and the length of the wire run.

23 Why is it important to evaluate the voltage drop in DC circuits?

Answer: Depending on the nominal voltage of the system, the voltage drop and associated line losses can be significant percentage of the system’s electrical output when using small gauge wires.

24 What three methods are commonly used to locate the rafter centers when on the roof?

Answer: Using the sounds of a hammer thumping the roof, using a stud finder, or looking at the fascia board/rafter interface.

25 Why mount the PV array at a level 8 to 10 cm above the roof?

Answer: Mounting at this level allows air circulation below the array that can cool the cool the modules and also allows rain to run off the roof.

26 What are the two instruments needed to properly perform the maintenance and troubleshooting tasks for a PV system?

Answer: A digital voltmeter and a dc ammeter.

27 During routine maintenance why is it important to check the voltage and current level at various points in the PV system?

Answer: Checking and recording the voltage and current levels at various points will assist in identifying problems now and can be use for future reference.

28 Where is a good place to check the open-circuit electrical characteristics of the strings in the PV array?

Answer: The best place is a fused combiner box.

29 What are the characteristics that should be measured and recorded in Question 3 and how are they determined?

Answer: Each string's dc electrical characteristics of open- and closed-circuit voltage should be measured with the digital voltmeter. Most likely the amp connections of the voltmeter can be used to measure the open-and closed-circuit current levels if the amp level is less than 10 amps in the circuit. For current level greater than 10 amps, a dc ammeter will be needed to measure the levels.

30 If you open a disconnect switch while checking the continuity of the grounding system and the ground is broken, what needs to be done and why?

Answer: If the grounding system's continuity is broken when you open a disconnect switch, the ground wire has been installed improperly. According to the National Electric Code to maintain a safe system, the ground wire can not be broken by any disconnect. The switch needs to be rewired to break only the hot leg in some circuit or both the neutral and the hot legs in other circuits – the equipment ground must remain connected at all times.

31 Give three sources or causes of damage to roof top components of a PV system.

Answer: Damage to roof top PV system component can be caused by the sun, the wind, hailstones, animals, and/or people.

32 During maintenance you discover that one string in the combiner box has a much lower open-circuit current level compared to the other strings from the PV array. Give two possible causes and explain how you would fix each problem.

Answer: Some modules in the series string are defective, i.e they may have defective blocking or bypass diodes of have some internal parallel connections that are broken, loose, or dirty. Replace these modules. Parallel connections between modules in the string may be loose, dirty, or open – clean and connect them tightly. The string may be shaded – remove the shade source. The modules in the string may be dirtier than the other strings in the array – wash off the modules (do all the array while you are at).

33 When checking the array string open-circuit voltages, what are two conditions that would cause a low voltage reading compared to the other strings from the array?

Answer: The wire connecting the modules in the string to each other or to the junction box or combiner box or inverter may by too long or too small for the string's output current level. Rewire with appropriate sized wire for the length and load. effective blocking or bypass diodes may need to be replaced.

34 If you were measuring the open-circuit current level of a string and the level dropped suddenly, stayed low for 10 seconds or so and then jumped back to the level you first measured, what is the most probable explanation for the event?

Answer: A cloud passing overhead shaded the modules in the string.

35 Why wash the PV modules whenever maintenance is scheduled?

Answer: Washing the modules removes dust, dirt, and other derbies that in effect shade the PV material in the module.

Chapter VII HVAC PROFESSION

Part 1 – theoretical lecture

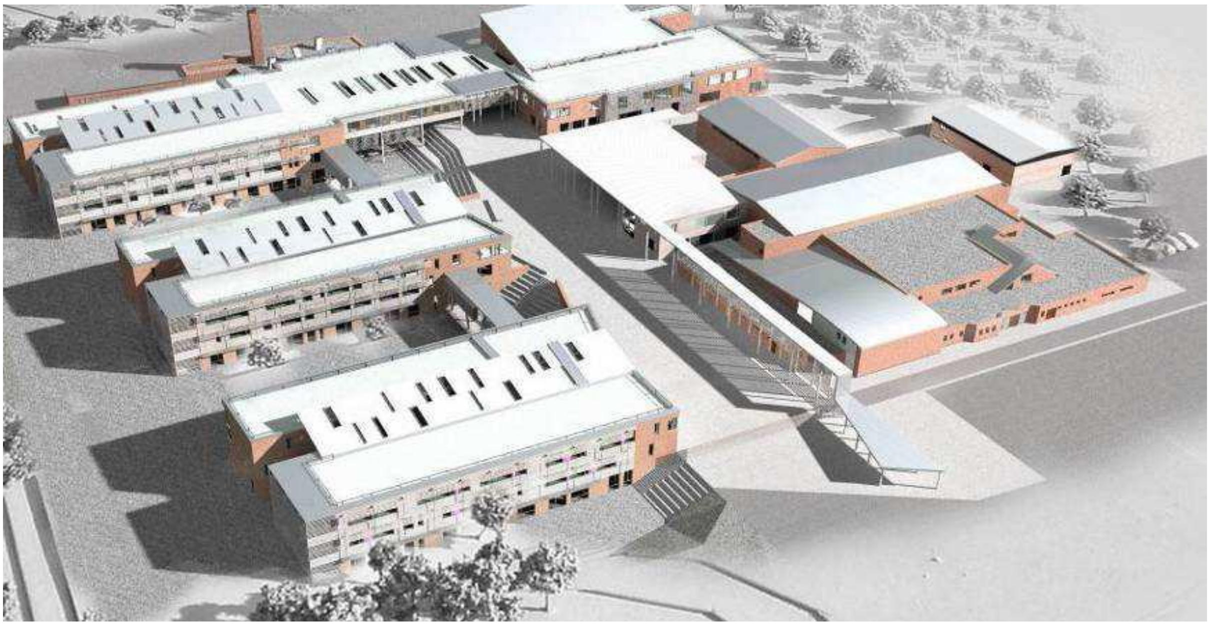
Presentation of GAHE system and installation according to students' manual:

1. Pipe transport
2. Pipe storage
3. Digging the trench
4. Installation of the pipes
5. Inspection of AWADUKT Thermo system after connection
6. Backfilling
7. Special requirements for AWADUKT Thermo pipe systems.
8. Health and safety issues
9. Case studies – different projects variants comparison and discussion

Case studies[1]

1. QE School, Wimborne, Dorset

- Flow rate: 36,000 m^3/h
- 3 Tichelmann grids, each 60m long
- DN1200 header pipe
- 60 AWADUKT Thermo runs of DN250, total length of 3,500m
- BSF *'Pathfinder'* school



2. Sutton Life Centre, Surrey

1st grid:

[1] Source: Ground-Air Heat Exchanger CPD – REHAU Ltd.

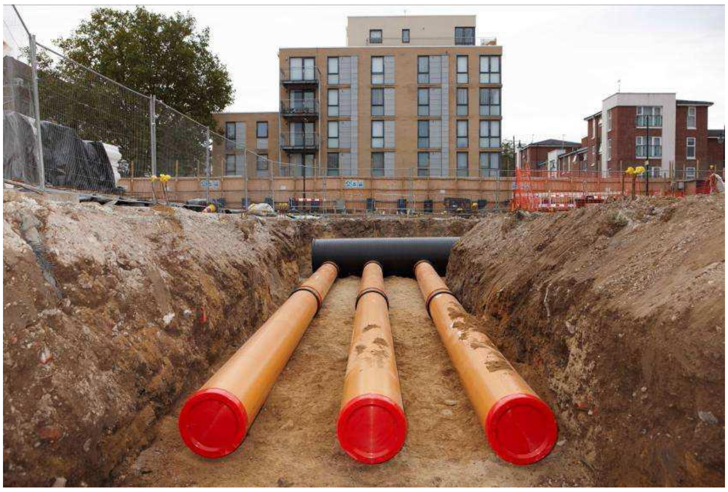
- Flow rate 2,880 m^3/h
- 26m of DN500 header pipes
- 11 x AWA Thermo runs of DN200 (each 18m long)

2nd grid:
- Flow rate 7,200 m^3/h
- 52m DN750 header pipe
- 35 x AWA Thermo runs of DN200 (each 30m long)


3. **Joseph Rowntree School, York**
   - Flow rate: 3,240 m^3/h
   - 24m of DN800 header pipes
   - 13 AWADUKT Thermo runs of DN250
   - Total length of 210m


4. **Holy Trinity C of E School, London**
   - Flow rate: 1,700 m^3/h
   - 228m of DN400 pipe & 84m of DN500 pipe
   - 3 separate grids serving different classroom areas


5. **Tuke School, London**
   - Flow rate: 9,000 m^3/h
   - DN1050 header pipes
   - 5 x 30m runs of DN 500 AWADUKT Thermo
   - Special methane resistant NBR seals




6. Carclaze School, Cornwall

- Flow rate: 3,457 m^3/h
- DN500 AWA Thermo header pipes
- 16 x 30m runs of DN200


7. Wembley Primary School, London

- Flow rate: 10,440 m^3/h
- 30m of DN800 header pipes, total length of 360m
- 20 AWADUKT Thermo runs of DN200


8. Treehouse Trust School, London

- Flow rate: 7,800 m^3/h (3 grids x 2,600 m^3/h)
- Pre-fabricated DN500 header pipe
- Each grid has 8 x DN200 pipe runs of 18m long
- Total length of GAHE pipe = 432m

9. Ray Park Community Centre, Essex

- Flow rate: 2,700 m^3/h
- 12m of DN400 header pipes
- 5 x AWADUKT Thermo runs of DN250
- Total length of 150m

10. The Lakes - Yoo 6, Gloucestershire

- Air flow rate = 900 m^3/h
- 4 runs of AWADUKT Thermo DN 200
- DN 315 header pipe
- 160 luxury houses over next 3 years

11. Lisburn Assessment Centre, N. Ireland

- Flow rate: 2,600 m^3/h
- 3 grids using DN250 and DN315 AWADUKT Thermo
- Total length of pipe = 180m


12. Property in Lower Basildon, Berkshire

- Air flow rate = 174 m^3/h
- 2 runs of AWADUKT Thermo DN 200
- Design and installation by Starkey Systems


13. Nairn Academy, Scotland

- Flow rate: 700 m^3/h
- Header pipe DN 250
- 3 x 30m AWADUKT Thermo runs of DN 200
- Extension to existing school


Part II – practical exercises

Students during their classes will go through practical exercise how to calculate the outcome for required building parameters. Software tool will be used for the following calculations:

1. Calculation of minimum outlet temperature at given duct length.
2. Calculation of maximum outlet temperature at given duct length.
3. Calculation of minimal duct length at given required minimum outlet temperature.

At least one computer for two students is needed.

Test part

Answers in bold (if multiple choice)

1. What Geoexchange system is used for?
   a) heating only
   b) cooling only
   c) heating and cooling
2. Specify at least two types of pipe loop installations.
   a) … Horizontal
   b) … Vertical
   c) … Submersed in a pond or lake
3. What is the minimum depth of below-surface pipes in horizontal loop systems?
   a) 1.0m
   b) 1.5m
   c) 2.0m
4. Specify at least two advantages of ground-source energy.
   a) ...Energy savings for heating and cooling
   b) ...Reduction of CO_2 emissions
   c) ...Renewable and sustainable energy source
5. What applications is a Ground-Air Heat Exchanger (GAHE) used for?
   a) domestic only
   b) commercial only
   c) domestic and commercial
6. What materials are pipes for GAHE systems made from?
   a) ceramics
   b) copper
   c) Polypropylene (PP)
7. For a GAHE system, what is the minimum distance between pipes and the minimum distance from the building?
   a) 1.0m
   b) 0.5m
   c) 1.5m
8. What should be the approximate gradient for GAHE system pipes?
   a) 1%
   b) 2%
   c) 3%
9. What size of pipe is typically used for domestic purposes?
   a) 200mm
   b) 500mm
   c) 1000mm
10. What is the AKWADUKT calculation tool used for (list at least one purpose)?
    a) ...Calculation of minimum outlet temperature at given duct length (winter)
    b) ...Calculation of maximum outlet temperature at given duct length (summer)
    c) ...Calculation of minimal duct length at given required minimum outlet temperature.

Chapter VIII PLASTERER PROFESSION

Presentation of plasterers work and systems for x-ray protection - method of a lecture supported by multimedia presentation.

Part I – theoretical lecture

– prepared using the Manual for Plasterer:

Job description.

Scope of plasterer's tasks.

Presentation of product

Presentation of technologies used.

Presentation of products' technical parameters.

Presentation of the Knauf system.

Discussion. Questions and answers session.

Part II – practical exercises

(1 or 2 days)

Implementation and discussion of particular tasks by an instructor. Then teams carry out tasks by themselves, supervised by an instructor.

Discuss the dimensions of walls and their forms and shape. Dimensions of a wall should allow for plastering to take place.

Required tools - description

Required materials:

Barite plaster must be made of cement CEM II BS 32.5 and barite aggregate. As an aggregate, barite sand of granulation about 0-4mm, specific mass of at least 4.25 g/cm3, and a minimum of 90% $BaSO_4$ content should be used.

Barite plaster - net material usage in dry state for 1m3 of mortar:

cement CEM II B 32.5 S	420	kg
STAB H2 admixture Chrysostom	2.52	kg
barite / aggregates and flour /	2950	kg
Water	246	l
Total	3616	kg

Note: The aggregates in their natural state contain 5% moisture, therefore the amount of water should be reduced by 5%.

The mixture formula is shown in table 1.

Table 1: Formula of barite mixture.

I. MATERIALS LIST

ID.	Aggregate / cement name	Disposition number	Supplier	Density
1	Barite powder		Surico	4,3
2	Barite 0-4		Surico	4,25
3	Cement II B-S 32,5		Górażdże	3.07

II. AGGREGATE ANALYSIS

Acc. to the list	sieve size (mm)									
	<0,125	0,125	0,25	0,5	1	1	4	8	16	31,5
1	8,8	12,2	17,9	21,7	21,9	13,4	4,1	0,0	0,0	0,0

III. MIXTURE COMPONENTS [kg/m3]

ID.	Component name	Dry state [kg]	Humidity [%]	Natural state	For the mixture volume – V-0,5 m3
1	Barite powder	450,00		450,00	225,00
2	Barite 0-4	2500,00	0,00	2500,00	1250,00
3	Cement II B-S 32,5	420,00	0,00	420,00	210,00
4	Water			246,00	123,00
5	CHRYSO STAB H2			2,52	1,26

Practical show of plastering – by an instructor – and discussion on subsequent actions, shown in the photos below:

a) b)

Figure 2. a) Barite aggregate, b) a bag of barite powder.

a) b)

Figure 3 a) Dosing Chryso Stab H2 (for metered water volume), b) dosing of cement and barite flours.

a) b) c)

Figure 4 a) Mortar mixing, b) wall cleansing, c) wall damping.

a) b) c)

Figure 5 a) Laying the first plaster layer, b) laying successive plaster layers, c) top coat application.

Practical exercises for training participants / 3-person teams

Independent performance of basic jobs supervised by an instructor – all works necessary for plaster preparation.

Inspection of work carried out by the instructor.

Summary of workshops, FAQs, remarks and conclusions.

Practical test

Independent performance of a selected element of a plasterer’s work.

Credit and rating of completed work (by instructor).

Test part

Answers to sample verification test questions (questions from Manual for Plasterer):

1. **Describe the occupational profile of a plasterer**

   A plasterer deals with the application of plaster layers (made of lime, cement, cement and lime, gypsum, gypsum and lime, stucco) and the application of dry plaster to the walls and ceilings of buildings and construction facilities. A plasterer prepares plaster mortars and is familiar with the types of components used to produce these and the rules of their composition. Currently, plasterers increasingly use factory-prepared ready-made mortars. Before starting plastering, they prepare the base and brick up any holes in walls and ceilings. They apply plaster to convex or concave architectural forms, particularly in historic buildings, e.g. on cross vaults or coffers, and they apply towelling plaster on the cornices. Plaster layers are applied using manual tools or plastering devices and machines. A plasterer operating plastering devices must be familiar with the methods of their operation and maintenance.

   The plasterer's tasks also include fixing air grates, hooks and other components to the surface of the plastered wall or ceiling. During repair works the plasterer may install scaffolding which does not require authorization by the Office for Technical Supervision, and mount hoisting winches for transporting materials and tools.

   A plasterer should be precise, capable of sustained physical effort, focused, physically fit, able to distinguish colours, persistent and patient.

   Plasterers work both inside and outside, standing, with their hands raised.

2. **List and characterize at least three tools used by plasterers for application of ordinary plasters**

   In their work, plasterers use a variety of bricking and specialist tools, designated exclusively for plastering.

- Trowel - to apply mortar,
- Masonry scoop - to apply liquid mortar (plaster bucket),
- Masonry hammer - for example, for removing mortar from any wall leakage.

3. **List and characterize the tasks included in the plastering process, which can be mechanized**

The actions which constitute the process of plastering (which can be mechanized) are:

- Preparation of mortar, during which the following tasks should be performed:

    - Loading mortar ingredients to the mixing device,

    - Mixing mortar components,

    - Mortar passing through the sieve,

- Transport of ingredients and / or semi semiproducts

- Horizontal
- Vertical,

- Application of subsequent layers of plaster, including:
  - Spreading of mortar,
  - Leveling of applied layers,
  - Surface obliteration.

4. **List basic devices included in a plastering unit.**

Plastering unit components:

- mixer – usually a drum mixer, allowing for mixing of mortar components;
- screen – usually a vibrating screen to separate overly large grains to prevent them from getting into the pump or the flexible conduit for transport of mortar, which could cause a failure of the entire system;
- pump and flexible dust - for vertical and horizontal transport of mortar;
- remote control and signalling system – allowing the operator of the spraying device to turn off the pump and to indicate the need to turn the pump back on;
- spraying device (spray gun)
- possibly with an additional air compressor – that is, a device allowing for break-up of the mortar stream and its application to the plastered surface.

5. **What should be taken into account when selecting the plastering unit for performance of a specific type of work?**

Choosing the plastering unit for the particular project, following aspects have to be considered:

- type of mortar for spreading of which the unit is capable
- type of pump
- maximum working pressure
- maximum range of device in horizontal and vertical directions
- volumetric usable capacity of blender
- volumetric capacity of mortar vessel
- pressure of compressed air
- type of power supply unit
- diameter of hose to which the plastering unit is adapted
- mass of the unit

6. **Provide the criteria of plaster classification.**

Plaster classification criteria:

- depending on purpose
- depending on placement
- with respect to mortar type
- depending on number of layers needed to obtain a desired plaster shell

7. **Compare the specific features of preparations preceding plastering of bases made of LECA concrete and cellular concrete**

A base made of monolithic ordinary concrete or light aggregate concrete should be even but rough. Therefore, the surface of concrete components made in boarding of whittled wood, plywood or metal, characterized by substantial smoothness, should be notched with hand or pneumatic chisels and then cleaned thoroughly of dust.

The old concrete base must be notched, even if made in boarding made of non-whittled wood.

The surface of prefabricated concrete components to be plastered should be clean, free from dust, grease or any mould lubricating agents. A surface with such residues should be cleaned by sand blasting or washed with water and detergent. It is also possible to increase the adhesion of plaster, using contact agents. On the surfaces designated for plastering, there can be small defects, but scaling of fragments of the prefab component surface is unacceptable.

Base consisting of ordinary concrete monoliths or light aggregate concrete can be plastered no earlier than 8 weeks after construction (in the summer), provided that the moisture content in the base does not exceed 3%. Immediately prior to plastering, concrete should be moistened thoroughly with water or a grounding agent.

A base made of cellular concrete blocks and slabs should be cleaned prior to plastering by removing mortar particles, as well as grease stains. It is also recommended to remove mortar from joints to the depth of 2 - 3 mm from the wall face. A base, prepared in this way, should be dry cleaned of dust using a brush.

8. **Explain the conditions that must be met to commence plastering works**

Plastering works can be commenced after completion of all:

- rough state works,
- flush-mounted installation works,
- bricking up of punctures and wall chases
- works associated with installation of window and door frames and incorporated furniture components.

Plastering cannot be performed immediately after construction of the wall, but only after the time necessary for completion of the process of their settling and contraction of the mortar, that is, after 4 to 6 months.

The minimum temperature for plastering is + 5 °C. However, it is necessary to make sure that after applying plaster, the temperature will not drop below 0 °C in the next 24 hours. If it is colder than +5 °C, it is necessary to use the appropriate means of protection.

Fresh outdoor plaster should be protected for the first 2 days against sun exposure for more than 2 hours a day. If the temperature exceeds +20 Celsius degrees, fresh cement, cement and lime and

lime plaster is to be moistened with water in the period of binding and hardening, which usually takes about one week.

9. List operations included in the process of application of ordinary plasters.

The process of application of ordinary plaster can consist of the following operations:

- determining of the plaster surface area (the so-called face), if provided in the requirements concerning the plaster category,
- applying of a plaster coat to the base,
- levelling of the coat surface,
- floating of the surface of the levelled plaster coat.

10. Describe the method of determination of plaster surface on the ceiling.

Determining of the plaster surface area on the ceiling can be done in two ways. The first way requires use of a large angle known as the square, of arm length of 1.5 or 2 m. To determine the ceiling area, it is necessary to:

1) Place the square near the upper corner of the wall, so that it leans with one arm against 2 nails situated on top of the vertical row of nails determining the plaster surface area on the wall;

2) Bring the second square arm closer to the ceiling, to the distance equal to the planned thickness of plaster (rendering coat + floating coat, total of 1.5-2.0 cm) and at the end of this arm drive a nail so that the length of its part sticking out is equal to the total thickness of the rendering coat and the floating coat;

3) On the vertical arm of the angle applied to nails on the wall, mark the position of the horizon line nail;

4) Go to the second corner of the same wall and apply to it an angle as described in clause 1, making sure that point marked previously on the vertical arm of the angle is located at the level of the horizon line nail, and then at the end of the horizontal arm of this angle, positioned in such way, drive in the ceiling a nail determining the plaster surface – as described in clause 2;

5) Repeat the activities described in clause 4 for both corners of the opposite wall;

6) Between the nails driven in the ceiling at the corners, stretch a wall parallel to the wall and drive nails along this rope at the intervals of about 1.5 m, levelling the nail heads with the rope line;

7) At the opposite wall, repeat the activities described in the previous clause;

8) Stretch the rope between the subsequent pairs of nails on the opposite walls and drive nails along the rope at the intervals of about 1.5 m, levelling their heads with the rope line.

11. Explain how the rendering coat, the floating coat and the finishing coat should be applied.

The rendering coat is the first layer, applied directly to the base. It ensures adhesion of the rest of plaster to the base, therefore it should be bound very strongly. The rendering coat thickness is 4+6 mm. The type of mortar and mode of performance of the rendering coat depends on the base type. On ceramic material, stone, wood wool slabs, the rendering coat should be made of thin cement or

cement and lime mortar. The mortar is applied with a trowel or a bucket, throwing it with strong gestures, so that long spatters are created. The rendering coat can be applied after preparation of the screeds or earlier. In the first case, it is necessary to make sure that the screed face surface is not splashed, and if it is splashed – they have to be cleaned gently. In the latter case, the surface is not splashed, but it is necessary to hurry up with marking the surface of plaster to make sure that the rendering coat does not bind too quickly. If this happens, the rendering coat must be moistened thoroughly with water to ensure good adhesion of the floating coat. On a wooden base with lathing or a mesh, the rendering coat is thrown with a trowel and pressed with a long float. The first layer of mortar can also be applied to the wall directly from the float. To this end, the float with mortar should be applied to the wall and moved in zigzags bottom to top, pressing it lightly. The thickness of the first layer of plaster, applied in this way, together with mesh, should not exceed 20 mm. After the rendering coat hardens slightly and it is moistened with water, the second layer is applied – the floating coat. This task is very significant, labour-consuming and requiring substantial skills. The floating coat thickness is 15-20 mm. It can be applied:

- with a trowel from the box,
- with a trowel from the board,
- with a bucket,
- with a float.

Regardless of the mode of application of the floating coat, a substantial part of the mortar falls off the base: on the walls – 30-35%, and on the ceilings 40+50%. Mortar, which has fallen off, is to be picked up and after mixing in the box applied again, making sure that no dirty mortar is used. Application with a trowel is performed in a way similar to application of the rendering coat. Application with a bucked is much more effective, since the plasterer is able to apply 4 times more mortar in comparison with the trowel. Buckets cannot be used to apply fast binding mortars (gypsum or gypsum and lime mortars), as they are quickly plastered up with it. Application of mortar with a trowel from the board is often used during plastering of ceilings. It consists of the following activities:

- putting mortar from the box on the board,
- putting mortar from the board on the trowel,
- throwing mortar on the surface.

After levelling of the floating coat, it is possible to apply the finishing coat. This layer is to be applied after binding of the floating coat, but before it hardens. The finishing coat is made of thin mortar, more greasy than the rendering coat and the floating coat, made of sifted sand. In order for the finishing coat to bind well with the floating coat, it should be moistened thoroughly prior to application of the finishing coat. The finishing coat is applied with a trowel to establish a layer 1-73 mm thick, it is levelled with a long float and – after initial hardening – finished with a float.

12. What are the basic rules of safe work during plastering using mechanical devices?

During operation of the plastering unit, the following rules of occupational health and safety apply:

- assembly and disassembly of the unit components should be conducted by at least 2 persons; it is necessary to maintain special caution
- the employee operating the unit must have protective goggles, and if the working time is to be longer than 4 hours during 1 day, it is also necessary to use hearing protectors;

- it is prohibited to turn on the unit without the screen screwed to the charging hopper;
- particular care is necessary during closing and connecting of the gear-motor to the mixer or liquidation of the so-called mortar plug in the hose; it is prohibited to perform these activities without protective goggles;
- after each activation of the safety valve, it should be rinsed thoroughly;
- no defects can be eliminated during operation of the unit;
- during any repairs, the main switch must be in position “0”, and the main power supply conductor must be disconnected from the plug at the control box
- only employees with power supply qualifications can repair the power supply system;
- as the unit is being connected and turned on, the conductors and electrical equipment must be dry.

13. What equipment should be used by plasterers to make their work more safe?

Preventive means associated with plasterer’s work are as follows:

- Wearing of the appropriate working shoes and clothes and the appropriately selected and applied means of personal protection, such as gloves, goggles, semi-masks, reflective jackets, hearing protectors, helmets;
- Maintaining of order in the work area and in the surrounding area;
- Use of scaffoldings consistent with the technical requirements, only after their acceptance by the supervision;
- Systematic control of the technical condition of scaffoldings;
- Use of adequate protection of structural openings during construction (e.g. use of protective barriers), and, if necessary, protective equipment to ensure protection against fall from heights;
- Use of appropriately selected ladders and lifts
- Use of appropriately selected electrical tools in good working order (tested);

14. Discuss the specific nature of application of barite plasters.

The rules of plastering with barite plaster are as follows:

- prior to plaster application, the wall should be cleaned and washed with water, plaster should be applied in layers and the number of layers depends on the plaster thickness
- application of plaster of thickness of 30mm ensures protection against radiation
- thickness of layers applied:
  i. first layer 2-5 mm
  ii. second layer 5-10 mm
  iii. third layer 6-12 mm

iv. finishing coat 2-3 mm

- barite plaster is to be laid in layer, and each layer of thickness of 5 m is to be applied after binding and before drying of the previous layer. The first layer is to be thrown strongly, perpendicularly to the wall, to fill the gaps between bricks
- barite plaster is to be mixed constantly in the concrete mixer to avoid falling of barite to the bottom.
- the total plaster layer thickness should not exceed 3mm. If plaster of thickness of 30mm is applied, metal meshes are to be used or plaster is to be applied on both sides.
- during hardening, due to its high specific gravity, barite plaster is characterized by strong settling, which results in cracking; therefore, it must be applied in layers.
- during plastering of protective walls and ceilings with barite plaster, the room temperature during work and in the first 15 days should not be lower than 15 Celsius degrees, and for 10 days, the plasters are to be washed with water to prevent cracking due to drying too fast.

Under the ceiling, to enhance adhesion, it is necessary to use a mesh, e.g. Rabitz net. If cracking occurs, remove the entire plaster coat and apply it again. In the floor, lead metal sheet is placed on a smooth underlayment and secured against damage with e.g. an additional layer of underlayment; afterwards, the floor finish is applied.

15. Discuss the specific nature of installation of radiation protection shields (by Knauf company).

Construction and assembly of a Knauf wall ensuring protection against radiation should be conducted as follows:

A light division wall built as a stand with a metal load-bearing structure according to DIN 18183 and the drywall at the top is largely consistent, when it comes to construction and assembly, with the reliable Knauf walls mounted on metal stands W 111 /W 112. A significant difference is the lead sheet lamination of construction slabs of thickness, which must be consistent with the project of protection against radiation, devised by the investor, and thorough protection of joints with self-adhesive tape of lead sheet. Depending on the noise protection and fire protection requirements, a Knauf wall protecting against radiation may be provided with a single or double lamination layer.

Prior to commencement of assembly, to save time, it is good to apply self-adhesive Knauf tapes, made of lead, of appropriate thickness, to the previously cut UW profiles for connecting the walls to the ceiling and floor on the side exposed to radiation. UW profiles, shielded against radiation, are then fixed to the face and vertically to the ceiling and the floor; afterwards, CW profiles are mounted and also provided with self-adhesive lead tapes. Finally, the Knauf radiation protection shields are fixed (all contacts and joints are to be provided in a manner ensuring protection against radiation). Filling and closing of joints is to be conducted in accordance with the manual. In places, where electric sockets are planned, radiation protection are fixed using two screws.

Construction and assembly of radiation protection ceilings.

- K 111: Knauf boards ensuring protection against radiation (b = 625 mm) on a wooden load bearing structure (like slab ceiling Knauf D 111) fixed with screws Knauf TN 45, but longitudinally.

- K 112: Knauf boards ensuring protection against radiation (b = 625 mm) on a metal load bearing structure (like slab ceiling Knauf D 112) fixed with screws Knauf TN 35, but longitudinally.

The following are applicable to both systems: maximum intervals between screws of 150 mm; lead equivalent equal to thickness of lead sheet according to the radiation protection project; securing of contact points of the long edges and slabs or load bearing profiles using self-adhesive lead tapes (thickness equal to the lead equivalent of the boards); securing of contact points of the short edges using self-adhesive lead tapes; levelling of other strips or load bearing profiles with strips made of lead or other material.

Chapter IX ROOFER PROFESSION

Trainer's guide - ROOFER
SOLAR PHOTOVOLTAIC SYSTEMS INSTALLER

(the whole module with all the shemes and the picture on the CD Rom)

This module is divided into 3 parts:
I - A theorcal part (about 1 day to 1 ½ day)
II - A practical part: (1 day)
III – An assessment part: (½ day to 1 day)
The different parts included in this trainer's guide can (have to) be adapted by the trainer according to his pedagogical choices and to the level of his trainees.
Thus, the more scientific aspects and some exercises will only be provided if the level of the group allows it.
Annexes are added to give some more examples and may be replaced by local examples, more attractive for learners.
This pedagogical tool is a proposition that must be taken into account by the trainer, but it can be adjusted in accordance with the written educational objectives, which do not vary.
The level of the final assessment should not be modified.

I - theoretical part

Here is the first part of this course corresponding to the theoretical part of the training module:

Duration: 1 to 1 ½ day
Objectives:
At the conclusion of the training, the trainees will be able to:

- Define photovoltaic solar energy;
- Explain the operation of a cell and a photovoltaic module;
- Design a photovoltaic system;

Prerequisites:

Basic knowledge of electricity: (Voltage, intensity, energy, power, law of ohm, law of the nodes and laws of the meshs)

<u>CONTENT: (SEE CD Rom)</u>

I GENERAL

Below are presented some boards resulting from documents carried out by **Bernard Multon** available on the site: http://e-mecatronique.bretagne.ens-cachan.fr/course/view.php?id=35

- See pictures and comments in the CD Rom for **Wind turbins – Photovoltaics - Marine Current - Geothermics - Vapor Solar Ststems**
- See pictures and comments in the CD Rom for photovoltaic systems connected to the network
- See statistics and comments in the CD Rom the Growth of the photovoltaic production
- See pictures and comments in the CD Rom for **The Solar Radiation in France and on our planet**
- See pictures and comments in the CD Rom for the Characteristics of the radiation in France and in the world
- See pictures, shemes and comments in the CD Rom for Orbit of the sun according to the geographical place and explanations about AZIMUTH

II SOLAR ENERGY (see more explanations on the CD Rom)

The solar radiation depends on:

II 1) Atmospheric Effect

The part of energy received on the surface of the ground depends **on the thickness of the atmosphere** to cross. This is characterized by the number of air mass **(AM)**.

The radiation which reaches the sea level at midday in a clear sky is 1000 W/m2 and is described as a radiation of **the air mass "1" (or AM1).** When the sun moves lower in the sky, the light crosses a greater thickness of air, losing more energy.

Since the sun is at the zenith during only a little time, the mass of air is permanently larger and the supplied energy is lower than 1000 W/m2.

The scientists gave a name at the standard spectrum of the sunlight on the surface of the ground :

AM1.5G or AM1.5D.

- The number "1.5" indicates that the course of the light in the atmosphere is 1.5 times superior with the shortest course of the sun, i.e. when it is with the zenith (correspondent with a slope of the sun of 45° compared to the zenith).
- "G" represents the "total" radiation including the direct radiation and the diffuse radiation
- the letter "D" represents only the direct radiation.

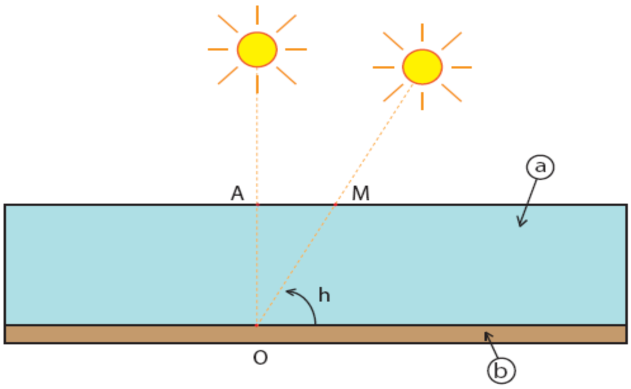


Fig. 2 a: Diagram of the Air-mass

a) Atmosphere b) Ground

Standardization:

The standard conditions of the qualification of the photovoltaic modules are: a spectrum AM1.5 under an illumination of 1000W/m² and a temperature of 25°C.

The solar panels manufacturers specify the performances of their material under standardized conditions quoted above (S.T.C.: Standard Test Conditions).

II.2) Other factors

In addition to the atmospheric effect, the solar irradiation also depends on:

- the orientation and the slope of surface,
- the latitude of the place and its degree of pollution,
- the period of the year,
- the moment of the day,
- the nature clouds layer.

The combination of all these parameters produces variability at the space and time of the irradiation during the day.

The best slope of the photovoltaic solar panels for a use during the year is that of the latitude of the place where the sensors (thus approximately 45° in France) are installed. However, actually the constructive arrangement of the dwelling, often determine the slope.

By convention, AM0 is the solar radiation out of the atmosphere.

The solar radiation can be broken up into 3 components:

- The direct radiation, which is the directly received by the sun
- the diffuse radiation, which is consisted by the light diffused to the atmosphere
- the albedo, which is consisted by the light reflected by the ground. It depends on the nature of the ground (snow reflects the rays more than the vegetation).

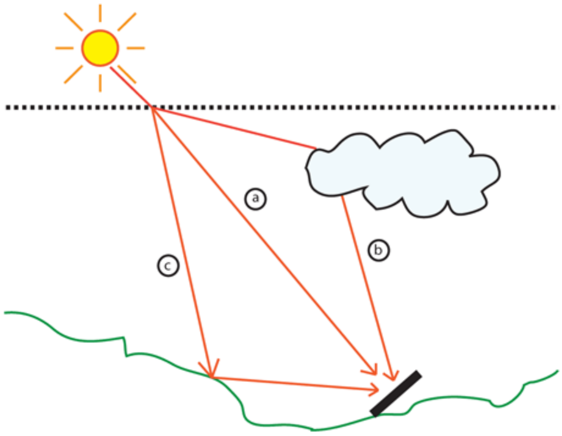


Fig. 2 b: Solar radiation

For the direct radiation, it is necessary to take into account the cosine effect. When the rays are perpendicular to the surface then the radiation is maximum. When they are not perpendicular, they irradiate a greater surface, the perceived radiation is thus less intense. It is for that that the solar panels are tilted in order to collect more direct radiation.

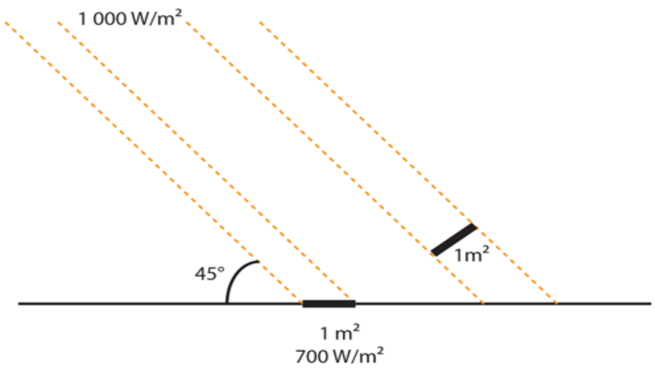


Fig.2c : cosine effect

On the contrary, in zones which have a very often covered sky, the diffuse radiation can be more significant than the direct radiation, thus it is more interesting to put the solar panels in direction of the vault of heaven.

III) PHOTOVOLTAIC SOLAR ENERGY (See more explanations, shemes and statistics on the CD Rom)

Two direct applications of the solar energy:

Production of electrical energy (photovoltaic effect), **treated here**

Production of heat (untreated in this course)

III.1) Principles of operation of a cell PV

The periodic structure of the atoms in a solid, involves energy bands prohibited for the electron and each material is characterized by a prohibited bandwidth (gap) expressed in eV whose value determines the nature of the material (conducting, semiconductor, insulator).

We call Ev as the maximum energy of the first authorized energy band (valency band) and Ec the minimal energy of the second energy band allowed (conduction band). The prohibited bandwidth Eg, equals to: $Eg = Ec-Ev$

Under certain conditions, the photons whose energy is higher can make an electron pass of the valency band in the conduction band thus leaving a hole in the valency band.

If the electron and the hole when released are quickly collected, they can take part in an electric conduction. So we can define the criteria of an ideal photon electron converter:

- The operation of collection requires a significant local electric field on the level of the creation of the electron-positron pair, which eliminates the conductors. It requires moreover materials with sufficient conductivity, which eliminates insulators;
- The semiconductor materials whose prohibited bandwidth lies between 0,7 and 4 eV are photovoltaic materials of the solar spectrum.

The PN bond under illumination, characterized by a significant potential barrier on the level of the bond and carried out starting from photovoltaic semiconductor materials, is the solution currently most widespread of the photovoltaic converter. For the ideal photovoltaic cell, one considers that:

- Any photon of energy lower than Eg is not absorbed and crosses material without transmitting energy to the electrons;
- Any photon of energy higher or equal to Eg is completely absorbed and creates a pair electron-positron pair;
- Any electron created takes part in conduction (not at recombination);
- The output voltage of the ideal basic cell is Eg/e (e is the electron load. 1,6 × 10-19 C)

If we accxept a PN bond from low thickness to a luminous flow, electron-positron pairs are created by the photons whose energy is higher than the prohibited bandwidth of the material. the resault is an increase of the reverse current’s proportional saturation to a luminous flow.

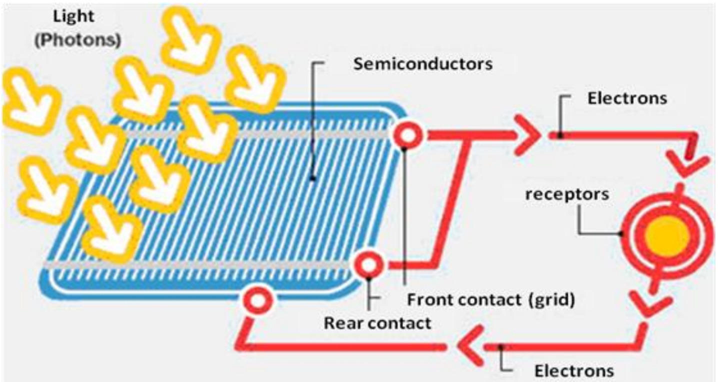


Fig. 3 F: Direct transformation of luminous energy into electric power

III. 2) the manufacture of a PV cell

<u>Raw materials</u>

Silica (silicon dioxide) is the raw material of a photovoltaic cell. It is the most widespread element (25% of the mass of the earth's crust) after oxygen, on earth.

Silica is appeared as a hard mineral. In nature, one finds it in great quantity in:

detrital sedimentary rocks (sands, sandstone),

metamorphic rocks,

magmatic rocks.

The extraction of silica is carried out in silica careers.

In 2010, the annual production of the silica careers in France rises to approximately 8 million tons.

Extraction and purification of silicon

Silicon (Si) is extracted from silica (SiO_2) thanks to the following simplified chemical reaction

This reaction is carried out in a light-arc furnace because it requires to dissolve the silica. The temperature of the furnace can reach 3 000 °C. The power of the furnace can go up to 30 MW, in order to engage the chemical reactions.

Actually, the reaction of the reduction of silica to silicon results from a great number of intermediate chemical reactions.

The power of the furnace can go up to 30 MW, in order to engage the chemical reactions.

The purity of the silicon obtained in liquid form is 98%, insufficient for the photovoltaic applications.

Purification of silicon

Silicon should be still purified to obtain the final nessecary purity of 99.99 %.

Obtaining the silicon ingots

Polycrystalline silicon (gray color):

Liquid silicon is put in a crucible of graphite. The technique is simple and little énergivore.

Polycrystalline silicon is obtained by casting out ingots in moulds in which takes place a slow cooling, about a few tens of hours. We obtain the final cubic ingots. This form is required in order to optimize space when the plates (obtained by cutting in plates of the silicon ingots) are placed in series on a photovoltaic module.

Single-crystal silicon

One of the methods to manufacture single-crystal silicon is the method known as of Czochralski. Silicon is placed in a crucible quartz and is maintained liquid by using heaters. When the surface is at the limiting temperature of solidification, a single-crystal seed is plunged. Silicon is solidified on this seed, according to the same crystallographic orientation. One slowly draws the seederm to the top, with a rotational movement, while thoroughly controlling the temperature and speed.

Obtaining the photovoltaic wafers

The cylindrical ingots (single-crystal silicon) or parallelepipedic (pollycristallin silicon) of silicon obtained at the end of the stage of solidification are then sawn in fine plates of 200 micrometers thickness which are called "wafers". The cut of the ingots is carried out by a wire saw:

Taking into account the low thickness of the sections to cut out (300 µm), the main problem of sawing is the loss of cutting. In order to minimize these losses, the adopted technical solution is the saw with wire. Indeed, the typical loss of cutting (kerf) of the saws with wire is of 200 µm to 240 µm, which represente 55% less of loss compared to the saws with internal diameter (loss of cutting of 310 µm to 350 µm).

So with a saw with wire, one needs 570 µm silicon to produce a section of 350 µm. The phase of sawing represents an determining element in the production cost of the photovoltaic cells.

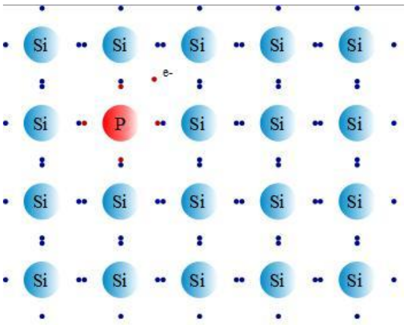
Doping of the semiconductors

Doping is a method that makes possible the creation of the P-N bond. That consists in inserting impurities into an intrinsic crystal to modify these electric properties. The doped semiconductor is then called "extrinsic semiconductor".

There are two types of doping: the N type (Negative) and the P type (Positive).

Doping of the N type

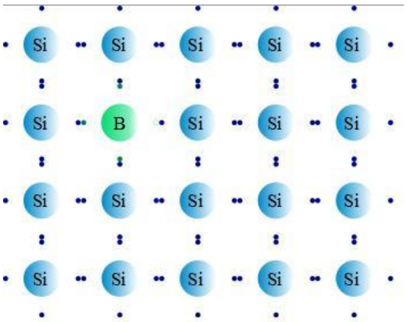
The doping of the N type consists in adding an atom of phosphorus within the crystalline structure of silicon. Phosphorus having 5 electrons on its external electron shell will join 4 silicon atoms, leaving an electron free:



This addition causes to give to the crystalline structure a negative total load.

Doping of the type P

The doping of the P type consists in adding an atom of boron within the crystalline structure of silicon. Boron having 3 electrons on its external electron shell, will join 4 silicon atoms, leaving free a hole:



This addition causes to give to the crystalline structure a positive total load.

When two different dopings (N type and P type) are created on both sides of the cell, the result is the creation of a constant electric field, by the presence of positive and negative fixed ions. The electric field makes possible the circulation of the electrons in only one direction, then we speak about photoelectric diode.

<u>Types of cells</u>

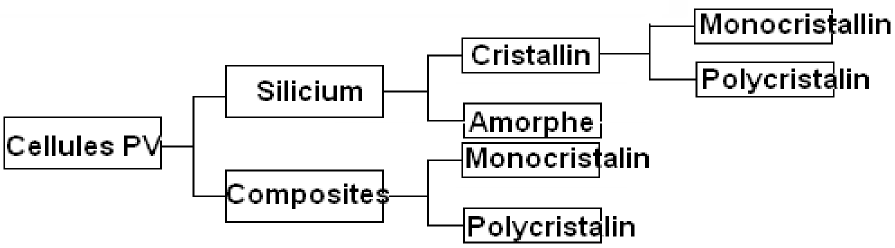


Fig.3.b: Example of a Photovoltaic cell

Fig.3 c: Characteristics for 1kW/m² and 25°C

III. 3) Yield of a cell

The yield of a cell is the ratio of the luminous energy received on the surface of the cell to the electric power produced by this same cell. The output of a photovoltaic cell would be approximately 85% if each photon could transfer all its energy to an electron. However, it is not the case when the transfer of the energy can be made only according to the specific energy band to each semiconductor. Thus, the photons with a lower energy than the standard value will not be able to take part in the photovoltaic effect and their energy will be converted into heat. Moreover, the photons with more energy can transmit only clean energy to the semiconductor and any excess is consequently lost. In the current cells, these 2 effects limit the theoretical yield of the cells to 50%.

Type	Cell yield (in lab)	Module (in lab)	Module (commercial)	Level of development
1st generation				
Single-crystal Silicon	24,70%	22,70%	12-20%	Industrial Production
Polycristallin Silicon	20,30%	16,20%	11-15%	Industrial Production
2nd generation				
Amorphous Silicon	13,40%	10,40%	5-9%	Industrial Production
Thin layer Crystallin Silicon		9,40%	7%	Industrial Production
CIS	19,30%	13,50%	9-11 %	Industrial Production
CdTe	16,70%		6-9%	Ready for production
3rd generation				
Organic cells	5,70%			Research Phase
Grätzel cells	11%	8,40%		Research Phase
Cellules multi-jonctions	39%*	25-30%**		Research Phase, exclusive production for special applications

* under concentration of 236 suns

** Module with triple bond GaInP/AsGa/G/Ge

Source: Solar systems – except special research solar series – July 2006

Fig. 3d: Yield of PV cells

III. 4) The photovoltaic module

A module consists of a number of PV cells connected electrically and encapsulated together for:

Obtain a sufficient tension thanks to connection in series of many cells,

Protect the cells and their metal contacts against the environmental conditions (especially moisture),

Protect mechanically the cells, which are very fragile.

The materials used for the encapsulation must have a long working life to resist the variations of temperature and the exposure of UV rays. The modules must also resist the mechanical efforts (transport, assembly, wind efforts) and the downpours of hail. Lastly, they must be able to be fixed easily on a structure.

Yield of a module

The power peak of a module corresponds to the electric yield of this one under conditions standards (1000 W/m², 25°C, AM 1,5). By knowing the surface of a module and its power peak, it is thus easy to calculate the yield.

The yield of a module equal to its power peak by m² (in W/m²) divided per 1000 W/m².

Example: a panel of 200 WC has a surface of 1,6 m². Its power peak by m² is 200/1,6 : 125 Wc/m². The output of this panel is : 125/1000 = 12,5 %

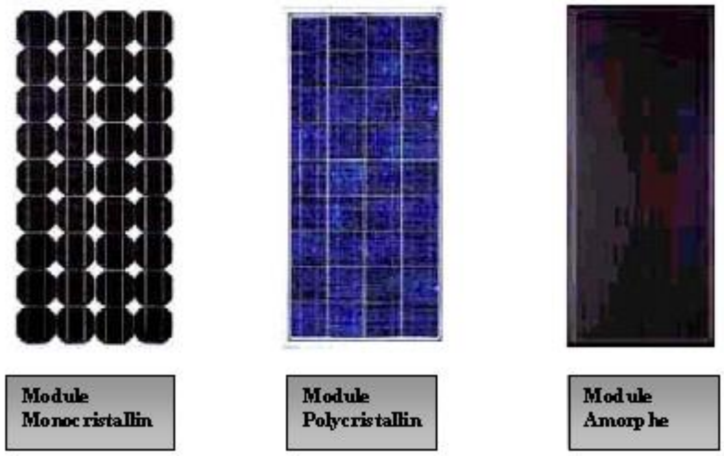


Fig.3e various modules

III. 5) Composition of a photovoltaic system (PV)

The system is composed by a group of components necessary to feed the application in all reliability.

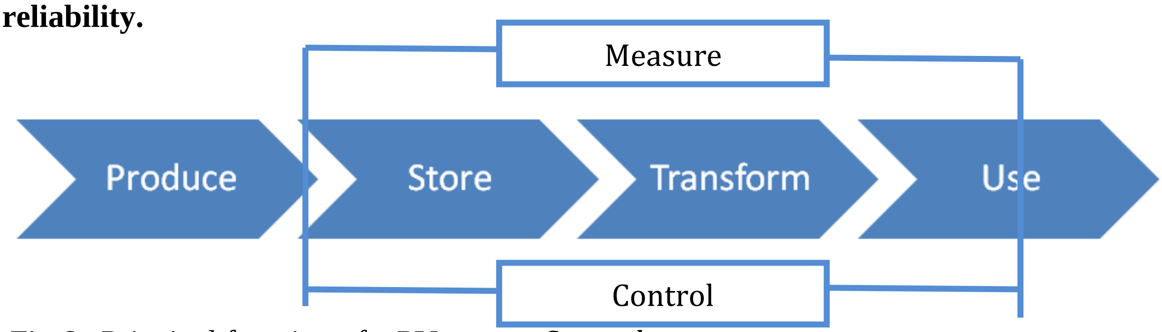


Fig.6 : Principal function of a PV system Control

IV TYPES OF SYSTEMS

IV.1) isolated or autonomous System

- *with the wire of the sun*

Fig.4a : Pumping with the wire of the sun

- Autonomous with storage

It depends completely on the photovoltaic field: In case of sun's absence, it draws the energy to the batteries. It is adapted at distant areas where connection with the network would be expensive. Examples: second country home, cottage, refuge, camp-sites, communication antennas etc…

Fig. 4 b: Autonomous system with storage

The autonomous hybrid system is generally used in distant applications requiring a good reliability of the electric production; nevertheless, it can be appropriate for any application having ideal conditions (high sunning, wind, diesel supply).

Fig.4c : **Autonomous hybrid system**

IV.2) System connected to the electrical supply network

There are two possibilities:

The system covers the applications of the user, and provide surplus electricity to the electrical supply network.

Fig.4d: Connection in only one point with the public network of distribution

The system injects all the produced electricity by the PV field, directly to the electrical supply network.

Fig.e: Connection in two points with the public network of distribution

V. STAGE OF DESIGN OF A PHOTOVOLTAIC INSTALLATION (see CD Rom)

The design of a photovoltaic project requires a precise and rigorous analysis of the situation and the data.

STAGE 1: Determine the total electric consumption.

The size of a PV system is defined by the electric consumption of the apparatuses. As higher is the consumption, more significant will be the size of your components and the cost of purchase will be high.

The Councils:

Use more apparatuses with low consumption.

- Lighting: Extinguish the apparatuses or lighting not used and to prefer lamps with low consumption.

- Electric household appliances: Prefer a gas cooker with your electric cooker. Use a refrigerator, washing machines and wash crockeries Energystar, prefer and support the short programs at tepid temperature. The air-conditioners and driers are strongly disadvised because they are very energy intensive.

- Heating: In the case of the heating of water, it would be interesting to use a solar water heating if you have a good sunning: you can reduce more than 50% the energy needed. The alternatives to the electric heating are wood, gas, geothermics as well as the solar liability when possible.

Consumption can be expressed in Wh/d or Ah/d:

Expression in Watthours per day (Wh/d)

Multiply the power which each apparatus consumes, by the number of hours during which the apparatus is used over one day.

Then add electric consumption by all the apparatuses; The result found is the total electric consumption used per day. It is expressed in Watthoures per day (Wh/d).

Expression in Ampere-hours per day (Ah/d).

Multiply the power which each apparatus consumes, by the number of hours during which the apparatus is used over one day; Then divide the result by the nominal voltage of the apparatus: So we obtain the electric charge per day of each apparatus.

Then add the electric charge of all the apparatuses; The result found is the total electric charge used per day. It is expressed in Ampere-hours per day (Ah/j).

STAGE 2: Evaluate the solar resource.

The Councils:

Check that the site does not pose constraints at the installation of the system (shade, difficult access to the site, etc…). Ask the following climatic data of the place at the local weather station:

Minimal daily sunning;

Average and extreme ambient temperatures in °C;

The latitude of the place

More the sunning is higher and the average temperature normal, the more your area will be favourable for exploitation with photovoltaics.

The solar resource

The weather station of your area can give you one of the two following values:

The daily sunning, which is the number of hours per day during which an exposed surface of 1 m^2 will receive a solar power of 1000 W; it is expressed in hours/day

The solar radiation, which represents the quantity of solar energy collected by a surface of 1 m^2 exposed to the sun during one day. In other words, it is equivalent to the maximum solar power of 1000 Watts received by a surface of 1 m^2 during a number of hours given during one day: It is expressed in Wh/m^2 / day.
Other units: kWh/m^2 / day, MW/m^2 / day.
By dividing the value of the daily solar radiation per 1000 W/m^2, we obtain the number of sunning hours per day.
Example:
A solar radiation of 3000 kWh/m^2 / day.

$$\frac{3000}{1000} = 3 \text{ hours sunning per day}$$

In addition to these data, it is also necessary to define the variability of the temperature of the area (average temperature and extremes) making it possible to determine the choice of the battery, to evaluate the loss of power of the PV modules and the wire specifications.
The latitude of the place allows determining the **optimal slope** of the PV modules in order to collect the maximum of the solar radiation.

STAGE 3: Define the type of systems to be installed.
- System connected to the network (to consult the UTE C 15-712);
- autonomous System;
- Solar-Wind hybrid System.

Power of the photovoltaic field
The whole of the power produced by the panels of the field, must satisfy the electric consumption of the application plus the real losses generated during the operation of the system (ex: cleanliness of the modules, increase in the temperature, falls of tension in the cables, etc…).
So the photovoltaic power takes account of the system effectiveness, multiplied by the number of sunning hours must be equivalent to the electric consumption must satisfy: Power of the electric field = Consumption/(effectiveness X no. of hour per day).

Simple example of calculation:
An electrical appliance which functions 2 hours per day, one reads: P = 100 W; U = 12 V.
There are 3 sunning hours/day: 3 kWh/m^2 / day.
Your daily consumption = 100 W x2 hours/day = 200 Wh/day or 16,6 Ah/day
20 % of losses = 80% of effectiveness (generally the effectiveness is estimated at 70 - 90%)
Hours of sunning per day = 2
Power field = (200 Wh/j)/(0.80 X 3 h/j) = 83,3 W
1 photovoltaic module of 100 W_C / 12V, will be necessary.

STAGE 4: Determine the necessary photovoltaic power for the installation.
The necessary photovoltaic power is the power which the whole of the photovoltaic modules must provide to meet the requirement in electric power for your application, at every conditions.
It is calculated compared to the total electric consumption, the daily sunning, and the effectiveness of the components of the system (battery, PV modules, inverter, wiring etc…).

The photovoltaic module

The size of a PV module is defined according to its exit power expressed in Watt peak (Wc), which can vary between 20 and 400 W_C. A PV module is presented under the criteria of maximum power (peak), nominal voltage of operation, maximum tension, and maximum current.

- Maximum Power or peak: It is the most significant parameter on the chart of the module. It is evaluated under conditions STC (strong sunning of 1000 W/m ^{2}, ambient temperature 25°, solar spectrum AM 1.5).

It is the point of maximum power of the module, equivalent to an ideal operation. Most of the time the module will not function with this power, unless an optimizer of power is used. Under these conditions one STC also guaranteed a minimum of power which is slightly lower than the maximum power.

- Maximum Tension: Just as the power peak, the maximum tension that a module can provide is the tension peak produced under conditions STC. It must be higher than the tension of the application (ex: U_{max} between 17 and 18 V to be able to charge a battery of 12 Volt and from 34 to 36V (losses included) to charge a battery of 24V).

- Maximum Current: It is the maximum intensity produced by the module under conditions STC (I_{max}). It has its importance for the choice of the regulator, the size of theconnection cables and the calculation of protections.

- Nominal voltage: It is the tension to which the PV module functions, the modules will cabled in series to reach the tension of the system or the battery for an autonomous system.

- Temperature NOCT: Certain charts indicate the operating temperature of the cell, the NOCT (*Nominal Operating Cell Temperature*) or temperature which reaches the cell inside the module in open circuit under a solar power of 800 W/m ^{2} at an ambient temperature of 25°C and a wind of 1 m/s. A too high NOCT decreases the effectiveness of the module. The standard value lies between 40 and 50°C. Also is recommended a good ventilation and a clear color behind the module.

- Temperature coefficient: Certain cards mention the temperature coefficient which indicates the loss of power of the module according to the increase in the temperature. Typical value, -0.45 %/°C per cell.

- Guarantee and certification: Very often the modules sold on the market have a guarantee minimum 20 years with a reduction of the maximum power of exit for this period of 10%; Also the certification of the module (standards CEI-61215, IEEE-4262, 503-cec-jrc) guarantees its quality to you.

- Shade: The surrounding obstacles (trees, buildings, etc…) on the area of the application, can produce shades on the PV modules, which decreases not only their yield but also can cause damage due to an overheating. It is thus imperative to choose the area of the modules and to use, if necessary non-return diodes and diodes of derivation to mitigate the problem of shade.

STAGE 5: Determine the capacity of the battery

The battery holds a very significant role in an autonomous photovoltaic system because it stores energy and restores it when the application requires it. It is thus significant to determine well its size and its capacity starting from the following parameters:

The total load while running (Ah/jour);

The number of days of autonomy;

Depth of maximum discharge (PDD) of the battery;

The temperature and its factor of correction.

Characteristics of the battery

- Rated capacity: It is the maximum quantity of energy which a battery contains (under ideal temperature of 25°). It is expressed in Amp hour (Ah).

- State of load: It is the percentage of the quantity of energy available in the battery to moment T.

- Depth of discharge (PDD): It is the maximum percentage of energy which one can withdraw from a battery. It should not be discharged beyond this value, in order to prolong its duration of life.

- Temperature: The variation in temperature influences the yield of the battery. This one has an ideal operation at ambient temperature of 25°C;It is thus necessary to envisage a thermal regulation if possible to maintain its duration fo life.

- Nominal voltage: It is the standard tension of the battery. It also corresponds to the tension of operation of the autonomous system. Ex: Tension 12V, 24V, 48V…

- Rate of discharge: It is the time necessary to entirely discharge the battery. Let us suppose a battery of capacity of 100Ah and current of discharge of 5 a: The rate of discharge will be: 100Ah/5A is 20 hours; It is noted C/20.

- Rate of refill: It is the quantity of current which it is necessary to reload a battery in a given time (time of the rate of discharge). Let us suppose a battery of 100Ah and rate of C/20 discharge: The rate of refill will be 100Ah/20h is 5 A.

- Cycle and lifespan: It is the number of sequences of charge/décharge, which a battery with its depth of discharge can undergo. It determines the performances of the battery and its lifespan.

- Numbers of days of autonomy: It is the duration which the battery can feed the installation while running, without being reloaded nor damaged.

Types of batteries

One distinguishes in the systems with renewable energy, the batteries Acid-Lead and the Cadmium-nickel ones. The Cadmium-nickel are much more expensive and are used only in very particular cases. On the other hand batteries Acid-Lead of the open type and Acid-Lead of the closed type are used in the autonomous solar systems with an original cost low.

Researches the characteristics of : Lead acid batteries (open + closed)

STAGE 6: Determine the size of the regulator

The regulator protects the battery against the overload from current coming from the PV module and the major discharge generated by the consumer. Here are the essential parameters to know:

Its nominal voltage,

Its current of entry on series types;

Its current of entry on shunt types;

Its output current;

The current of total point.

Characteristics of the regulator

There are regulators of charge/décharge indicated for the domestic applications where the excesses of consumption are forecaster, and those only load will be used when the system does not present any risk of accidental discharge. The other function of the regulator can be the monitoring and the safety of the installation, the research of the maximum point of power, or the ordering of refill of the battery by other sources.

- Nominal voltage: It must be able to support the tension in open circuit of the PV module and is approximately twice its nominal voltage.

- Current of entry: It is the current of peak load coming from the modules and that the regulator can control under a given tension. Choose 1.5 times the current of short-circuit of the PV modules for a shunt regulator and 1.5 times the rated current of the PV modules for a series regulator.

- Output Current: It is the maximum current which draws the apparatuses connected simultaneously.

- Current of point: it is the transient current of certain apparatuses (Ex: The refrigerators) which the regulator must support. Generally it is equal to 3 times the transitory current.

- Protection: The drivers arriving at the regulator must be protected from the overloads, the inversion of polarity and the increase of the temperature.

<u>Types of regulators</u>

- Shunt Regulator:

Is appropriate for small power applications, comprising 1 or 2 PV modules. When the battery reaches the full load, the current coming from PV modules is derived intermediary by a switch (transistor).

- Series Regulator: Is appropriate for average power applications whose current of PV modules is higher than 10 A. When the battery reaches the full load, the regulator shuts off the current coming from the PV modules.

- MPPT Regulator: Is appropriate for the great power applications. It guarantees a maximum recovery of the power coming from the PV modules by permanently measuring the current and the tension; However it is necessary to consider the losses which occure with this technique. Also this regulator can work in a vast range of temperature.

<u>Characteristics of the inverter</u>

In a photovoltaic installation, the inverter occupies a central place. It will transform the D.C. current delivered by the photovoltaic installation into a AC current compatible with the network.

One distinguishes the continious part noted DC. upstream, connected to the modules of the inverter, and the alternative part noted AC, connected to the network downstream from the inverter.

The continuous current and the tension producted by the photovoltaic modules are transformed, via the inverter, in a current and an alternating voltage compatible with the network.

In France, the characteristics of the network are as follows:

- Frequency of 50 Hz

- effective Tension of 230 V

The selection criteria of the inverter are numerous and are based on the requirements of the electric charge and the installed system. Here are most relevant.

- Nominal output: It is the power which the inverter can deliver under permanent operation. Technically the nominal output of the inverter must cover the sum of the powers of all the electric charges CA which one wishes to use at the same time. However in practice it is rare that all the apparatuses function simultaneously. The choice of the nominal output will then be based on the total power of all the apparatuses functionning together.

The power of the inverters being variable, it is necessary to trust the power that the inverter can deliver uninterrupted over a long period: For example 20% of the nominal output during 30 min or one hour.

- Power of point: Certain apparatuses like the refrigerators or the engines draw a very significant current during their starting (3 to 10 times their nominal output), thus producing a very high power, called power of point or overload. The inverter must be able to support this overload during a short period.

- Output: It is the principal criterion in the choice of an inverter, because one wishes to maintain the system effectiveness high. The output with full load is not a relevant factor of choice; it is the output with partial load which is significant, because the power required by the load is always lower than the nominal output of the inverter. Thus an effective inverter is that which will have a high output (> 90%) on a great range of possible powers.

Consumption with vacuum or on standby: In a system where the inverter is connected permanently on all the loads, it happens that the totality of the load is not in function (for example

the night). The inverter thus functions in neutral and consumes power unnecessarily. So it is equipped with a device with a mechanism of detection of power for stop and automatic reset on detection of load, so that consumption in this mode is the weakest possible.

Entry Tension: In the case of an autonomous system, the entry tension corresponds to the set up tension of the system. One can to also choose this tension to use the following method, according to the demand for electricity Ca (D):

- if D < 2 kw then Ue = 12 VCC;

- if D ranging between 2 and 5 kw then Ue = 24 or 48 VCC;

- if D > 5 kw then Ue = 48 VCC and more.

In the case of a system connected to the network, the DC entry tension must be higher (For example 120 VCC and more), by respecting the serialization of the PV modules.

Output voltage: It must correspond to the supply voltage CA of the apparatuses, and be regulated to remain stable with lower deviations 5% no matter the input voltage and the electric charge are.

Form wave: The apparatuses which the inverter supplies must be able to support the form of wave of the exit of the inverter. It is thus necessary to know the tolerances on the tension and the frequency of each apparatus supplied by the inverter

Harmonic distortion: Certain electronic instruments (example lamps with ballast) can create harmonics which deform the output signal of the inverter; what can cause a disfunction of the application (undesirable heating, overloads, disturbance of other apparatuses etc…). The inverter must be able to maintain the harmonic distortion the lowest possible.

Types of inverters

The types of inverters can be classified in two categories according to the application or the system set up:

- 1. Inverters for autonomous and mixed systems

- 2. Inverters for systems coupled with the network

1. Inverters for autonomous and mixed systems

Inverter with modified sinusoidal wave: It is appropriate in the majority of the apparatuses (except certain sensitive electronics components) and represents a good quality-price ratio. Its signal is produced by commutation thanks to thyristors, which enables him to support strong overload and to produce a harmonic distortion at the exit, enough tolerable to be able to supply the majority of the engines.

Inverter with pure sinusoidal wave: It is indicated for the loads which require a form of wave of higher quality, because its output signal is similar to that of the public network. It produces low distortion. However, it has neither the capacity of overload, nor the effectiveness of the inverter with sinusoidal modified wave. These models can incorporate a regulator of load for battery.

Inverter with square wave: It is inexpensive because its quality of wave is poor and is used for small loads. Certain apparatuses like the refrigerator do not function with such an inverter. Make the choice of such an inverter only if the electric charge tolerates such a wave.

2. Inverters for systems coupled with the network

Inverter for coupling with the network: They are indicated for the applications connected to the public network, because they produce few harmonics, agree at the frequency of the network, have an automatic disconnection and measure the maximum point of power (MPPT) of the PV modules Nevertheless it is necessary to take account of the requirements of the companies of electricity (monitoring of the tension and frequency etc…) for a better choice of these apparatuses.

These inverters can go from 100 W to hundreds of kw. They generate their alternating signal by using the network like source of signal and synchronization or by using the passage to zero of the

network to synchronize itself. They are equipped with a transformer, in order to establish a galvanic separation with the network or then without transformer for a higher output. However using them, it is necessary to pay a detailed attention at the direct coupling with the network.

STAGE 7: Determine the power of the inverter

When the application is composed of apparatuses functioning in alternative electricity (AC), electricity that PV modules produce should be converted continuesly, in alternative electricity compatible and usable by these apparatuses. As soon as the number of apparatuses is significant, it is advantageous to choose a powerful inverter. The choice of the inverter is up the following parameters:

Its nominal output;

Its point or or maximum power;

Its yield or effectiveness;

Its form of wave

Electric losses

The losses in power occurring during operation in a conductor connecting two components is equal to the product of the resistance of the conductor to the square of the current crossing the conductor:

$$P_{pertes} = R(en\Omega) \times I^2 (en\,A)$$

- one knows the value of the resistivity **ρ** (rhô) of the conductor and his section (S).

$$R_T = \frac{\rho \times 2L}{S}$$

- there is the value of resistance per unit of length

$$R_T = R(\Omega / m) \times 2L$$

- ρ is the R esistivity of conducting material (in $\Omega.mm^2 / m$);

- L is the length of the conductor (in m);

- S is the section of the conductor (in mm^2)

In a general way one considers the real losses between the connections of the different components in a system with battery in a following way:

- Connection Electric Charges -Inverter;
- Connection Battery-Inverter;
- Connection Regulator-Battery;
- Connection PV Field -Battery.

It should be checked with each connection while going up to the PV field, the effective power (losses included) that must deliver the components. It is necessary to be ensured thereafter that the total provided power at the time of the design takes well account of all these losses, in the contrary case one rectifies the design.

STAGE 8: Determine wiring and protections

The choice of the types of the necessary electric cables to the interconnection of the components must be undertaken in an effective way to maintain the reliability and the good yield of the system.

Abacuses (charts) are proposed to determine the good section of the cables. In general, the conducting wire of these systems are made of copper and are dimensioned to produce ideally **1%** and **maximum 3%** of loss in tension at the wiring.

With regard to electric protections, the grounding, the lightning protectors, circuit breakers and the fuses are necessary to isolate and protect the electric circuit against all electric defects (Overpressure, overload, escape of current, temporary absence of tension, short-circuit). However, it is extremely possible that the components of the system have already their own protections; in this case it will not be useful to add some.

STAGE 9: Consider the real losses of the whole system.

Although one takes account of the specific outputs to each component at the time of the systems design, it is significant also to consider the losses caused at the conducting wire between each component during operation. Indeed, any conductor setting up an electric connection generates losses relevant at the resistance of the conductor during the passage of the current. According to these losses, it will be necessary to readjust the total power of the system.

The voltage drop in a cable equalizes with :

$$\Delta U = 2 \times R \times L \times I \quad d'où \quad \frac{\Delta U}{U}(\%) = \frac{2 \times R \times L \times I}{U \times 100}$$

- 2 represents the two conductors + and -;
- R is the resistance of the conductor to the temperature of the web (Ω/m);
- L is the length of the specified connection (in m);
- I is the maximum current crossing the conductor at the connection (in A).

Another way of calculating the voltage drop:

$$\Delta U = R \times I \quad où \quad R = \frac{\rho \times 2L}{S}$$

- R is the resistance of the cable to the temperature of the web (in Ω);
- I is the maximum current crossing the conductor at the connection (in A);
- ρ is the Resistivity of the conductor's material (in $\Omega.mm^2$ / m);
- L is the length of the conductor (in m) X 2 (+ and -);
- S is the section of the conductor (in mm^2).

One ideally requires a total voltage drop of 1%, if not 3%.

VI Architectural aspect and integration with the frame (see pictures and comments on the CD Rom

1 - Assembly the photovoltaic modules over the roof

2 - Integration on roof punt

<u>Pose photovoltaic modules on frames</u>

<u>Laying photovoltaic modules on ballast reservoirs</u>

<u>Pose photovoltaic modules out of bracket</u>

<u>Pose flexible photovoltaic membranes</u>

Integration of the photovoltaic modules on frontages

<u>The solar vertical boarding</u>

Integration of the photovoltaic modules in roofing units:

The roof is the structure covering the higher part of a building, making it possible mainly to protect its interior against bad weather and moisture. A roof is generally made up:

Of a frame, which could be made by wood, steel or reinforced concrete.

Of a cover, which could be tiles, slates, shingles, steel, corrugated zinc plates or sheet.

The frame assures the function of the structure carrying the cover.

The cover assures that the sealing is protected against the external factors (rain, snow, wind and possibly cold).

The photovoltaic modules assembled in roofing units replace the cover of the roof. So they must provide the functions of a cover of roof, namely the roofing and the sealing.

The photovoltaic installations assembled in roofing units are eligible with the premium of integration, contrary to the photovoltaic equipment posed over the roof.

The installation of the photovoltaic modules in roofing unit can be done only by depositing the cover. In fact the modules act as cover then.

The sealing of the roof must also be ensured by the photovoltaic modules. That can be carried out only by one attachment unit of the clever photovoltaic modules.

There are 2 great integrated systems making it possible to fix the modules on the roof while ensuring the sealing:

Integration Systems using sealing membranes

An impermeable plastic membrane is placed under the photovoltaic modules thus ensuring the sealing of the roof :

Some integrated systems of this type:

The attachment unit **INTERSOL** marketed by the Renusol-Ubbink company, adaptable to all type of photovoltaic modules.

The attachment unit **SOLARDELTA** marketed by the Conergy company, adaptable to all type of photovoltaic modules.

Integrated Systems, without seal, ensuring the sealing mechanically.

See APPENDIXEX on the CD Rom

II – practical part

Second part of this course corresponding to the practical part of the module on photovoltaic:

Duration: 1 day

Objectives:

- To inform on the photovoltaïc market
- To compare the various panels and their characteristics
- To apply the various techniques of assembly

Necessary materials and equipment (the quantity is accordant to the size of formation group)

<u>Necessary Equipment :</u>

- Computers and connection to Internet
- Catalogues of photovoltaic material
- Material of safety, conforms to the legislation (Individual Protection Measures: as much as trainees)

<u>Necessary materials:</u>

Various panels and different material corresponding to the possible techniques of assembly:

- Assembly on pole for plate roofs →vats - poles
- Assembly in superimpose →rails
- Assembly integrated for frontages and roofs

The course must be carried out at the language of the country, we leave to each trainer the free choice of the resources to be used. Nevertheless, in the case learners who are not/o r little accustomed to the use of the Internet , the trainer will have make previously a research for the relevant sites, exploitable for the course

.

I - The market, the resources

We'll speak about seeking, studying and comparing with the assistance of the trainer at the Internet or at the catalogues:

- : various photovoltaic modules proposed on the market

  →Various specificities and selection criteria according to the type of the installation
- various systems of installation and the necessary materials
- →the trainer will highlight the points of vigilance
- Guides of assembly accessible on Internet: these guides represent marks, and we leave at the appreciation of the trainer the choice of several guides.

II – Calculations for the dimensioning of the photovoltaic system to set up

The trainer in precondition must: remind /study /expound

II 1 - Various factors entering in account:

A - With – the place: The dimensioning of photovoltaic that your roof takes, depends of the roof's shape and size, the quality of the orientation as well as the accidents of the roof.

B - The principal systems from the dimensioning point of view are:

Photovoltaic systems **connected to the electrical supply network** where the total of the electric production inserts at the network

- ➔ In this case, the dimensioning will be made for the maximum of the production over the year.

2. Photovoltaic systems **for isolated sites**,

- ➔ In this case, dimensioning will be made for the most unfavourable month for solar irradiation, the way that the requirements in electric power are covered all the year with means of storage like batteries, for the use of energy in differed time.

3. The third system, **known as the wire of the sun**, uses directly the photovoltaic energy when it is produced, for example for pumping. In this case, it does not have there storage of the produced electricity which is directly used.

C –Orientation of the plan of the modules and slope of the solar panels (to be adapted for each country)

Orientation

Ideally, the solar modules must be directed straight to the South.

Slope

Moreover, for the slope of the solar panels, the thermal production depends at the year and thus their financial profitability, so it is significant to do not neglect this aspect.

The solar panels must be placed perpendicular to the sun to obtain an optimal result. The adjustment on the vertical level requires knowing the trajectory of the sun, according to the season and of the geographical place:

In France, in practice and for reasons of costs, the majority of the solar panels are with fixed slope: close to 45°

The table below gives for various slopes and orientations the annual solar irradiation per square meter at Lille, Lyon and Nice: (see CD Rom)

II – 2 Elements of calculation - Formulas

According to INES education,

Within the framework of project IEEA Energy Path

And financed by the ADEME

A photovoltaic sensor can be defined by its surface and its output but in general, it is its power peak, noted PC, which is the principal characteristic given by the manufacturers.

The power peak, PC of a photovoltaic sensor is the electric output which it can provide on an optimum load impedance under a perpendicular illumination of 1 kW/m² (spectrum AM 1,5) with a temperature of cells generally 25°C. The power peak is expressed in kilowatt peak (or kWc). In case of the electrical power created from the intencity of lightening the electric kw becams illuminated kW/m².

Illumination E is the luminous power received per unit of area in kW/m², this one varies from zero (the night) with the maximum value from approximately 1 kW/m² (at midday).

The irradiation is the intensity of lightening cumulated over a duration (year or day). The irradiation is expressed in kWh/m², which corresponds to a certain number of hours under an illumination of 1 kW/m². The power peak which delivers a photovoltaic module is precisely defined for this illumination. This number of hours under **a radiance Ir** of 1 kW/m² multiplied by the power peak corresponds to the produced electric power

The electric output Pel (in kw) which can provide a photovoltaic sensor at the power peak to nominal according to radiance Ir (in kW/m²) is calculated as follows:

$$\boxed{Pel = Pc \times Ir}$$

Pel: in kw -- PC: in kWc/1kW/m ^{2} (under an illumination of 1kW/m $^{2)}$ -- Ir (in kW/m ^{2}

The electric power Ea produced per annum (in kWh/an) according to the annual irradiation **Ira** (in kWh/m².an) is calculated as follows:

$$\boxed{Ea = Pc \times Ira}$$

Ea: in kWh/an -- PC: in kWc/1kW/m ^{2} (under an illumination of 1kW/m $^{2)\,--}$ Will go in kWh/m².an

Example of applications (without taking account of the losses):

A photovoltaic sensor of nominal output PC of 1000 WC is subjected to an incidental radiance Ir of 800 W/m² at the surface of the sensor. Which is the electric power output by this sensor?

Pel = PC X Ir = 1000 electric WC (/1 000 luminous W/m^2) X 800 luminous W/m^2 = 800 W electric

If the annual irradiation Ira incident to the surface of the sensor is 1.000 kWh/m^2.an (Town of Lille on a horizontal level), which is the energy delivered by this sensor of nominal output PC of 1000 WC?

Ea = PC X Ira = 1 000 WC (/1 luminous kW/m^2) X 1000 kWh/m^2 luminous per annum = 1.000 kWh electric per annum

III –Assembly of the panels

Size of the device: 3m^2 (average size of a device on a roof)

Methods: at small groups (2 trainees)

With the material and equipment envisaged according to the number of trainees, it will act in this part for the trainer to show and make carry out in small groups the installation of photovoltaic panels according to at least 2 possible techniques among those seen in the theoretical part:

- In overtaxation
- On frame (roof punt)
- On light vat (roof punt)
- In applied
- In boarding

<u>Note vigilance 1: safety</u>

The trainer will have to recall and make apply the necessary conditions relating to the safety of the specific building site.

The major risk is the risk of fall generated by work in height.

To respect the general principles of prevention in accordance with the article L 230-2 and L 230-3 of the Fair labor standards act from which extracted follow:


body protection


feet protection


hands protection


Caution


Protection against the falls


face protection


hearing protection


Electric danger

The port of the EAR following must be respected for all the operations of preparation, installation and test:

(recall of the pictograms)

 body protection

 feet protection

 hands protection

 Protection against the falls

<u>Note vigilance 2:</u>

The trainer will particularly take care the clear and sufficient explanations that will be given for the techniques of installation on the roofs (in overprinting or integrated).

Many films and guides of assembly are available on Internet and can be exploited for this purpose. These films being related to marks, we cannot indicate them here in a more precise way, but it is up to the trainer to make teaching choices..

III - EVALUATION

See final test, test picture and instructions for the correction on the CD Rom

Chapter X CONCRETE BUILDER PROFESSION

Concrete Reinforcement using Fibres: Lecture with multimedia presentation

Part 1 – theoretical lecture

Job description

Traditionally, concrete builders deal with all aspects of fabricating constituent elements of concrete structures, namely foundations, columns, beams, slabs and so on. Structural concrete is traditionally reinforced with steel bars or tendons specifically located in the structure to bear tensile stresses and thus optimise performance.

Concrete can also be reinforced by incorporating short fibres randomly distributed throughout the concrete matrix (normally proportioned mixes, or mixes specifically formulated for a particular application.). Fibres suitable for reinforcing concrete have been produced from steel, glass, synthetic (polymeric e.g. polypropylene, polyethylene, polyester, amarid, carbon) and natural resources (wood cellulose, sisal, coir (coconut), bamboo, etc). This is an important area of innovation in the concrete technology.

Fibre Reinforcement Concrete (FRC) can be an economic and useful construction material due to the flexibility in methods of fabrication. Long-term serviceability, crack control and substantial matrix tensile strength are just some of the benefits of including fibres. But there are a number of other relevant examples. Glass fibres may be used for pre-cast glass fibre reinforced concrete architectural cladding panels; steel and synthetic fibre reinforced concrete and shotcrete have been used in slabs for grade, mining, tunnelling, and excavation support applications instead of welded wire fabric reinforcement; etc. Two or more fibres can be used for reinforcement (Hybrid Fibre Reinforced Concrete) and/or with conventional reinforcement. .

Concrete can also be reinforced with composite bars made with carbon, glass or other types of synthetic fibres. Composite fibre-reinforced polymer (FRP) bars are pultruded bars consisting of unidirectional stretched fibrer in an epoxy resin matrix inserted in concrete beams, columns, slabs and walls.

Concrete Builder’s tasks

In order to carry out these tasks proficiently, concrete builders must have certain workplace skills, knowledge, and experience, namely:

1. Interpret the information contained in the design documents, technical specifications and work method statements;
2. Clearly understand the methods and characteristics of the tasks to be performed
3. Estimate quantities of material and tools needed to perform the work and set up resource requirements if needed;
4. Select and use a variety of equipment and tools to manipulate different materials and components (wood, steel, cement, etc.) and carry out relevant tasks;
5. Understand the composition and behaviour of concrete;
6. Deal with field conditions and monitor extremes of wind, heat, and temperature that can severely affect the durability of the final concrete structure;

7. Inspect the quality of work performed to fulfil the provisions of the specifications and take appropriate measures when non-conformities are detected, in accordance with standard norms.

Additionally, concrete builders must also:

1. Know how to identify site conditions, plant location, material storage and collaborate in organising the site;
2. Carry out housekeeping (including cleaning and maintaining work tools and machinery in good condition) and waste management operations;
3. Execute tasks according to project work schedule and coordinate them in conjunction with other running activities;
4. Liase with site management and contractors on progress of works, health and safety issues and report on work progress, accidents, near misses and unexpected difficulties.

Finally, all the tasks must be prepared and organized according to the general foreman's or site manager's instructions and according to technical drawings, method statement and specifications, applicable standards, norms and codes and other requirements such health and safety, environmental, waste, quality and other relevant requirements

Theoretical training – first day – "Fibres for concrete reinforcement"

There are a number of commercial fibres that can be used for concrete reinforcement. Table1 summarizes the types of concrete fibres according to the ACI Committee 544

Table 1

	Steel Fibre Reinforced Concrete (SFRC)	Glass Fibre Reinforced Concrete (GFRC)	Synthetic Fibre Reinforced Concrete (SNFRC)	Natural Fibre Reinforced Concrete (NFRC)
Composition	• Hydraulic cements containing fine or fine and coarse aggregate and discontinuous discrete steel fibres.	• Cement, sand, chopped glass fibre, water, and admixtures together into a mortar. • Chopped AR glass fibres: - 2 to 3% by weight (premixed); - 4 to 6% by weight (spray-up) [303] • Sand: cement ratio approx. 1:1 • Pozzolan cement replacement: silica fume, metakaolin, or other to reduce the permeability and alkalinity of the concrete	• Fibre types that have been tried in portland cement concrete based matrices are: acrylic, aramid, carbon, nylon, polyester, polyethylene and polypropylene.	• Coconut Sisal, sugar cane bagasse, bamboo, jute, flax, elephant grass, water reed, plantain, musamba, wood fibre (kraft pulp) Unprocessed natural fibre reinforced concrete: • Mix proportions for unprocessed natural fibre reinforced concrete cannot be generalized since there are a variety of natural fibres that can be used in conjunction with the other standard ingredients such as cement, pozzolans, fine aggregates, water, and admixtures. The types of natural fibres that can be used with these standard ingredients include: bagasse, sisal, jute, coconut, banana, and palm. • Cement that meets the ASTM standard specification C 150 or C 595 can be used. The type of cement recommended is Type I, although Type III (high-early strength)

				cement can be used in order to reduce hardening retardation caused by the glucose present in most natural fibres. • Aggregates should meet the requirements specified by the ASTM C 33 standard • Water to be used for the mix should be clean and of good quality. • Admixtures such as accelerating agents may be used in order to decrease the influence of the glucose retardant. If mild steel rebars are not used as additional reinforcement, calcium chloride could be used. Water-reducing admixtures and high-range water-reducing agents can be added in order to increase the workability when plastering. The use of organic-microbiocide is encouraged, for the prevention of bacterial attack of organic fibres. • Fibres: length may vary from 25 to 500 mm. Typical diameter values may vary from 0.10 to 0.75 mm.

	Steel Fibre Reinforced Concrete (SFRC)	Glass Fibre Reinforced Concrete (GFRC)	Synthetic Fibre Reinforced Concrete (SNFRC)	Natural Fibre Reinforced Concrete (NFRC)
Production methods	• Requirements: • Approved mixing, placing, finishing, and quality control procedures be followed. • SFRC delivered to projects should conform to the applicable provisions of national standards (e.g. ASTM C 1116). • Tightly bound fibre clumps must be broken up before entering the mix. • The method of introducing the steel fibres into the mixture be proven in the field during a trial mix. • Fibres must be dispersed uniformly throughout the mixture during the batching and mixing phase. • Mixing sequences include: • Add the fibres to the truck mixer after all other ingredients, including the water, have been added and mixed. Steel fibres should be added to the mixer hopper at the rate of about 45 kg per minute, with the mixer rotating at full speed. The fibres should be added in a clump-free state so that the	• Two processes: "spray-up" process and "premix" process. **a) Spray-up process**: • The process can be either manual or automated. • The process consists of simultaneously pre-mixing cement/sand mortar and chopped glass fibres and depositing the mixture from a spray gun onto a mould surface. Quality control requirements recommend the use of four percent alkali resistant fibre (AR-glass fibre) by weight of total mix. • Sprayed GFRC is manufactured in layers. Each complete pass of the spray gun deposits approximately 4 to 6-mm thickness. A typical 13-mm thick panel requires two to three complete passes. After each layer is sprayed, the wet composite is roller compacted to ensure that the panel surface will conform to the mould face, to help remove entrapped air, and to aid the coating of glass fibres by cement paste. Suction is then applied to either side of a permeable mould to remove excess	• Most widely used production method for all types of SNFRC is Batch mixing. Synthetic fibres are usually added to ready-mix concrete at the batch plant. Conventional placement methods are applicable, including batch placement and pumping. • Fibres are added to the wet mix directly from bags, boxes, or feeders. Collated fibre types require mechanical agitation during the mixing process to encourage the break up of fibre bundles and their dispersion through the mixture. Pre-packaged dry mixes that contain dispersed fibres and to which only water need be added are also available. Pre-weight fibre quantities in degradable bags are also widely used to facilitate batching. • After batching, placement techniques include all the standard methods such as batch casting, pumping, wet-mix shotcreting, and plastering. The use of dry-mix shotcrete for SNFRC is difficult due to the propensity for the relatively low density fibres, specific gravity of approximately 1.0, to be blown out either	• Unprocessed natural fibre reinforced concrete: • Two methods of mixing and placing: (1) wet mix and (2) dry-compacted mix. Wet mix: • Low volume fraction of fibres is used. • Water added to the mix has to take into account the high natural water content in natural fibres. The mixing procedure must comply with the ASTM C 94 process and portions of ACI 304 recommendations. Trial batches are recommended and a batching plant is required. The recommended mixing procedure is to add cement with water and additives to form a slurry. Then the fine aggregates are added. Finally, fibre is added and dispersed into the slurry. The sampling is to be done according to ASTM Practice C 172 and C 685. For compressive and flexural strength testing, ASTM C 39 and C 78 are to be followed.

	mixer blades can carry the fibres into the mixer. The mixer should then be slowed to the recommended mixing speed and mixed for 40 to 50 revolutions. Steel fibres have been added manually by emptying the containers into the truck hopper, or via a conveyor belt or blower as shown in. Using this method, steel fibres can be added at the batch plant or on the job site. • Add the fibres to the aggregate stream in the batch plant before the aggregate is added to the mixer. Steel fibres can be added manually on top of the aggregates on the charging conveyor belt, or via another conveyor emptying onto the charging belt. The fibres should be spread out along the conveyor belt to prevent clumping. • Add the fibres on top of the aggregates after they are weighed in the batcher. The normal flow of the aggregates out of the weigh batcher will distribute the fibres throughout the aggregates. Steel fibres can be added manually or via a conveyor.	water immediately after spraying. The spray-dewatering process is most suited for automation where the composite is transported over a vacuum system using conveyors. For AR-GFRC products, forms are normally stripped on the day following spray-up. Composites are then moist cured until they have attained most of their design strength (particular attention must be paid to curing due to the thin section of AR-GFRC components) **b) Premix process** • The process consists of mixing cement, sand, chopped glass fibre, water, and admixtures together into a mortar, using standard mixers, and casting with vibration, press-moulding, extruding, or slip-forming the mortar into a product. • Up to 5 percent by weight of ARglass fibre can be mixed into a cement and sand mortar without balling. Higher concentrations of fibre can be mixed into the mortar using high efficiency undulating mixers. • Mixing must be closely controlled to	by the shotcrete nozzle air pressure stream or by environmental air streams. Slip form machines pose no problems with SNFRC mixes. • Polypropylene fibres have been incorporated into concrete using several methods. They may be mixed as short discrete fibres of monofilament or fibrillated form. They can be easily dispersed in concrete matrices in volume percentages of up to 3% using conventional mixing techniques. • Acrylic fibres have been used in the Hatschek process, which is used to manufacture asbestos-cement board. Asbestos fibre conforms very well to the Hatschek process because these finely fibrillated fibres provide excellent filtration characteristics that keep the cement particles uniformly dispersed in the fibre/cement slurry and prevent segregation during vacuum dewatering. Acrylic fibres cannot perform this function due to their relatively large diameter and specific surface properties. Therefore, it is necessary that certain “process” fibres be used as filler in addition to acrylic reinforcing fibres to provide filtering characteristics and	Dry-compacted mix • The dry-compacted mix is generally used for industrial or • semi-industrial projects. In the dry-compacted mix, the volume fraction of fibre used is about 10 times the volume fraction used in wet mix. The fibres are in a saturated-surface dry condition for this type of mix. Trial batches are recommended. • The recommended mixing procedure is to add fibres in saturated-surface-dry condition to the cement and aggregates and then add a very limited amount of water. • Mixing can be done by hand, although mixing according to ASTM C 94 is recommended. For compressive and flexural strength, ASTM C 39 and ASTM C 78 are to be followed. • The dry mix samples are cast followed by the application of pressure since very little or no water is added to the mix. • The volume percentage of unprocessed natural fibres used in a mix varied from 3 to 30 percent

		minimize damage to the fibre in the abrasive environment of the mix. • Flow aids, such as water-reducers and high-range water-reducing agents, are commonly used to facilitate fibre addition while keeping the water-cement ratio to a minimum.	prevent segregation of fine particles. Generally, acrylic fibre is incorporated at 1 to 3 % by weight while process fibres are added at 3 to 6% by weight. Some examples of effective process fibres are kraft cellulose pulp fibre and polyethylene pulp fibre. • With the hand lay-up technique, higher fibre volume percentages (up to 12 %) can be obtained than with conventional batch mixing techniques (up to about 1%). Spray suction dewatering techniques can produce composites with as high as 11 % fibre by volume. • Consistency is commonly measured by a standardised slump test (ASTM C 43). An apparent slump difference should be expected when comparing non-fibrous and SNFRC for otherwise similar mix designs. In the case of hydrophobic fibres, there is no loss of water to the fibre, but the fibre will provide a plastic shear strength to the mix that will reduce slump. • Conventional ready-mixed concrete can easily be produced using monofilament or fibrillated fibres at 0.1 % volume with little loss of consistency as measured by slump. However, slump loss will increase	depending on the type of fibre used and the manufacturing procedure. Typical mix proportions • for coconut fibre reinforced concrete for both the wet mix and the dry-compacted mix are presented in Table 5.3. • 5.3.2.4 Placing and finishing—The placing and finishing of the unprocessed natural fibre reinforced concrete is dependent on the method of mixing used (wet mix or dry-compacted mix). Placing of the wet mix may be achieved by using conventional equipment. Internal or external vibrators should be used. Other properties such as workability can be measured by the slump test or the K-slump tester as per the ASTM recommended Penetration Test. Air content in the mix can be measured using ASTM C 231 or C 173. • For placing the dry-compacted mix, there is a need for a special type of formwork since the mix is dry and has to be compacted with some pressure within the formwork. Once the dry mix is placed inside the formwork, it is subjected to a

			more rapidly beyond this point. The slump loss is dependent upon the fibre length as well. Slump is often, though improperly, used as a measure of workability, and it is often said that the workability of concrete is reduced in the presence of fibres. However, with standard placement practices, fibre concrete will work, place, and pump readily. No additional mixing water is required and none should be added. Since the conventional slump test is an inappropriate measure of workability for FRC, it is recommended that the inverted slump cone test ASTM C 995) or the Vebe Test (ACI 211.3) be used to evaluate workability.	confining pressure of about 30 to 70 psi (0.2 to 0.5 MPa). This confining pressure is applied for a period of about 24 hours. Care should be taken not to apply a larger pressure than needed, since water (which is critical for hydration) may be squeezed out. The air content of the mix can be obtained • using ASTM C 231 or ASTM C 173. The unit weight can be obtained using ASTM C 130.

	Steel Fibre Reinforced Concrete (SFRC)	Glass Fibre Reinforced Concrete (GFRC)	Synthetic Fibre Reinforced Concrete (SNFRC)	Natural Fibre Reinforced Concrete (NFRC)
Equipment	• Equipment currently used for conventional concrete mixing and placing.	**a) Spray-up process**: spray gun, mould **b) Premix process**: standard mixers, vibrating equipment, press-moulding equipment, high efficiency undulating mixers.	• Equipment currently used for conventional concrete mixing and placing. • Equipment used in spray suction dewatering technique.	• The following observations can, nevertheless, be made, based on the existing literature [5.13]. • Unprocessed natural fibre reinforced concrete is more vulnerable than other fibre reinforced concretes in terms of durability. The highly alkaline pore-water in the concrete seems to deteriorate the fibres. • Durability can be substantially improved by replacing 40 to 50 percent of the cement with silica fume, since the addition of silica fume reacts with lime and considerably reduces the alkalinity of the pore-water. • Improved durability can be achieved by coating the fibre with suitable chemicals such as formic and stearic acid.
Safety	• Workers should be equipped with protective gloves and goggles.	• Workers should be equipped with protective gloves and goggles.	• Workers should be equipped with protective gloves and goggles.	• Workers should be equipped with protective gloves and goggles.

	Steel Fibre Reinforced Concrete (SFRC)	Glass Fibre Reinforced Concrete (GFRC)	Synthetic Fibre Reinforced Concrete (SNFRC)	Natural Fibre Reinforced Concrete (NFRC)
Applications	• Cast-in-place SFRC (e.g. highway paving; industrial floor-on-grade; repairs and new construction on major dams and other hydraulic structures, repairs and rehabilitation of marine structures such as concrete piling and caissons); • Pre-cast SFRC (e.g. utility boxes and septic tanks.); • Shotcrete (e.g. repair and reinforcing of lighthouses, bridge piers, slope stabilization); • Slurry Infiltrated Fibre Concrete (SIFCON) (e.g. impact and blast resistant structures, refractories, pavement repairs).	• Material system produces significant weight savings in non-structural architectural cladding panels and other concrete products; • Architectural component (doors, Windows); • General building (Roofing systems, lintels, hollow non-structural columns or pillar, impact resistant industrial floors, cellular concrete slabs);		

	Steel Fibre Reinforced Concrete (SFRC)	Glass Fibre Reinforced Concrete (GFRC)	Synthetic Fibre Reinforced Concrete (SNFRC)	Natural Fibre Reinforced Concrete (NFRC)
Regulations	• ACI Committee Documents • ACI 544.1R State-of-the-Art Report on Fibre Reinforced Concrete • ACI 544.2R Measurement of Properties of Fibre Reinforced Concrete • ACI 544.3R Guide for Specifying, Mixing, Placing, and Finishing Steel Fibre Reinforced Concrete. • 544.4R Design Considerations for Steel Fibre Reinforced Concrete • ASTM standards • A 820 Specification for Steel Fibres for Fibre Reinforced Concrete • National Standards • NP EN 14889-1:2008 Fibres for concrete - Part 1: Steel fibres - Definitions, specifications and conformity (EN 14889-1:2006)	• ACI Committee Documents • ACI 544.1R State-of-the-Art Report on Fibre Reinforced Concrete • ACI 544.2R Measurement of Properties of Fibre Reinforced Concrete	ACI Committee Documents • ACI 544.1R State-of-the-Art Report on Fibre Reinforced Concrete • ACI 544.2R Measurement of Properties of Fibre Reinforced Concrete National Standards • NP EN 14889-2:2008 Fibres for concrete - Part 1: Polymer fibres - Definitions, specifications and conformity (EN 14889-2:2006)	

Theoretical training – second day – "Producing Steel Fibre Reinforced Concrete (SFRC)"

The tasks required for producing SFRC are identical to those described in the Concrete Builder's tasks for ordinary concrete, with the exception that fibres that are an additional component that must be added to the concrete mix. The main features of producing SFRC are described under the following headings (follow the Concrete Builder Training Manual):

- **Composition:** SFRC is merely a product resulting from adding discontinuous discrete steel reinforcement fibres into a standard concrete mix (cement, aggregates, water and additives).

- **Fibre storage:** The steel fibres are usually delivered in big bags or boxes and should be stored in chronological order of delivery.

- **Preliminary tasks:** These are identical to those for conventional concrete.

- **Production methods**

    - Requirements:

        - Materials: Cement, aggregates, water, fibres

        - Equipments: Mixer or truck mixer

        - Tools: Ordinary tools used by concrete builders

        - Testing devices: Slump test device

    - Mixing sequence: Fibres may be incorporated either by adding them into the batched mixture or by adding them with the aggregates at the batching plant

        - Add the fibres *manually* into the concrete mixer (figure 1) or into the truck mixer (figure 2)

Figure 1: Manual insertion in the concrete mixer

Figure 2: Manual addition in the truck mixer.

- Add the fibres *mechanically* into the truck mixer (figure 3)

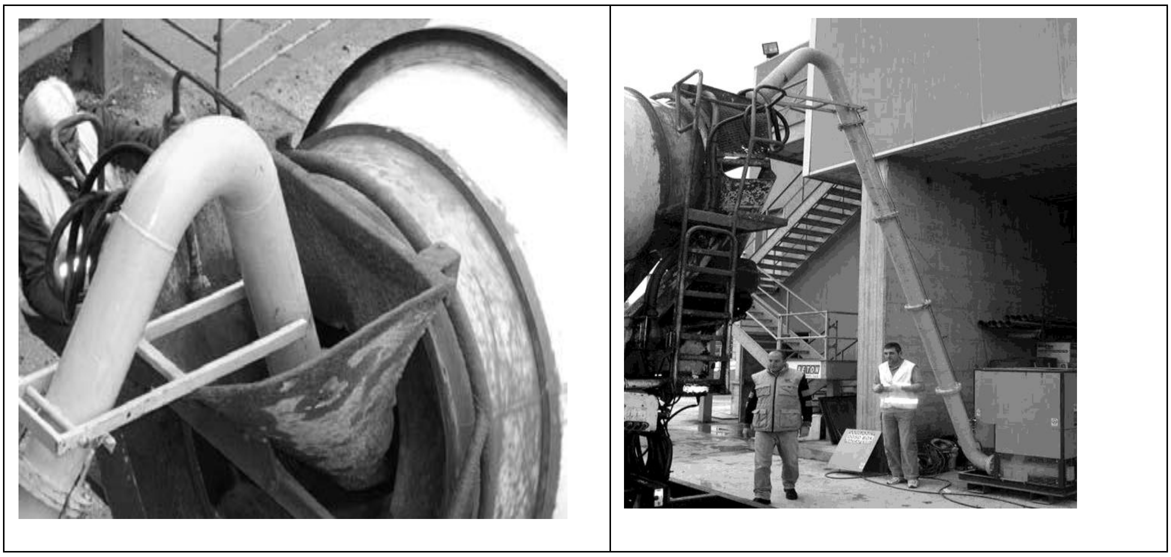


Figure 3: Mechanical addition in the truck mixer.

- Add the fibres to the aggregate stream in the batch plant before the aggregate is added to the mixer (Figure 4).

Figure 4: Manual insertion with the aggregates in the belt conveyor

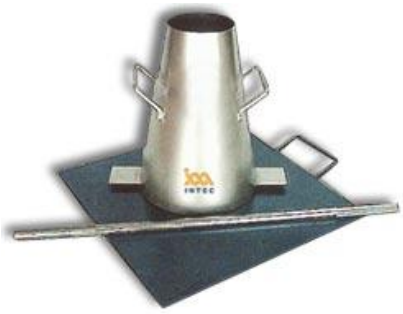
- Add the fibres on top of the aggregates after they are weighed in the batcher. The normal flow of the aggregates out of the weigh batcher will distribute the fibres throughout the aggregates. Steel fibres can be added manually or via a conveyor, like above.

- **Plant and tools:** Workers must use the same plant and tools as in conventional concrete for mixing, pouring, levelling and finishing

- **Safety:** Safety equipments are identical to those required for conventional concrete works

- **Workability:** Despite the performance gains conferred by fibres, their integration in the concrete mixture change the workability condition, especially if high quantities of fibres are used. The shape of fibres may also play a role because the more slender the fibre, the lower the workability of the mixture. The workability of SRFC must be evaluated by testing procedures that are identical to those used for conventional concrete (e.g., the slump test).

- **Testing:** Testing procedures are identical to those used for conventional concrete (e.g. slump test and inverted slump test, see figure 5).



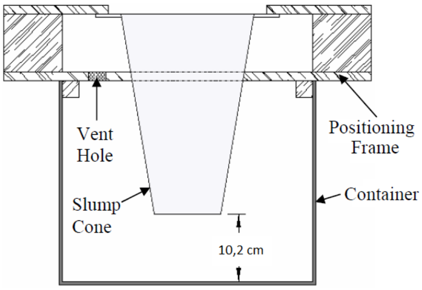


Figure 5: Testing devices

- **Concrete casting:** Identical to conventional concrete.

- **Concrete levelling and finishing:** Identical to conventional concrete.

Conclusions

The students should answer questions relevant to the theoretical part:

- What are the main fibres used for concrete reinforcement?
- What are the processes of placing steel fibre reinforcement into fresh concrete mass?
- What is innovative about concrete fibre reinforcement?
- What are the main benefits and drawbacks of using this technology?

Discussion

Note: Theoretical training will be carried out using a multimedia presentation (DVD) containing explanations, figures and tables

Part II – practical training

Practical training – first day and second days

The trainer will show and explain the procedure to produce steel fibre reinforcement concrete according to the lecture of the second day of theoretical training. The training sessions may take place in any current site environment and it will take two days.

Required tools and devices

- Materials: Cement, aggregates, water, fibres
- Equipments: Mixer or truck mixer
- Tools: Ordinary tools used by concrete builders
- Concrete scaffold elements (possibly with steel bar reinforcement)
- Testing devices: Slump test device

Practical installation procedure

The students will be divided into 3 groups. Each group will perform specific tasks related to each installation phase.

1st group: Insert fibres into a concrete mixer or truck mixer
2nd group: Produce and place fibre reinforced concrete into the mould
3rd group: Test fresh concrete using the test device provided

The groups will rotate so that each group gets the opportunity to perform each task. Different techniques of inserting fibres into the concrete mass and different concrete elements may be used if possible, according to the specific site conditions and availability.

The trainer will check each group to control the work and make suggestions or correct wrong procedures. Based on the work, the trainer will give a score to each group.

Discussion, exchange of experiences, FAQs, remarks and conclusions.

Test part

	Question	Yes	No
1	Fibres are an alternative reinforcement method to traditional rebar reinforcement.	X	
2	Fibre reinforcement is basically using fibre made reinforcement bars in the place of traditional steel bars.		X
3	Mixing fibres in concrete avoids the need for any other type of reinforcement.		X
4	The same type of concrete composition is appropriate for fibre reinforcement concrete.	X	
5	The use of fibres in concrete elements is limited to incorporating them in the concrete mixture.		X
6	Fibres are not useful for repairing concrete because they must be incorporated in the concrete mix.		X
7	External reinforcement is possible in concrete but fibres cannot be used for that purpose. Beyond steel bars, special strips made of other extremely resistant materials are also available in the market for that purpose.		X
8	There are many types of fibres that can be used for concrete reinforcement but steel fibres are structurally safer than other types, thus they are preferred.		X
9	There is no need for design when it comes to fibre reinforced concrete because the operator just has to incorporate a specified quantity of		X

	fibre in the mixture.		
10	Fibre reinforced concrete is not as safe as steel rebar reinforced concrete therefore special permission is required to use it on site and special health and safety conditions must be met by operators.		**X**
11	The pressure of concrete on the formwork significantly increases in the case of fibre reinforced concrete therefore extra resistance must be met by scaffolds.		**X**
12	Steel fibres for concrete reinforcement from distinct suppliers are very similar in shape, length and section. The distinction is based on the type of steel they are made of.		**X**
13	Cracking is more frequent when fibre reinforced concrete is used because an additional material is added to the traditional mixture.		**X**
14	There is only one way of incorporating steel fibres in the concrete mixture: By adding them in the concrete mixer or truck.		**X**
15	Workability is a big problem when steel fibre reinforcement is used because the concrete mass hardens much quicker than ordinary concrete		**X**
16	Special systems have to be used to control workability for steel fibre concrete because the presence of fibres prevents the use of common tools.		**X**
17	Steel fibres are usable for producing most concrete elements (slabs, beams, columns, and so on) whereas other types of fibres are only applicable to lighter elements (like prefabricated units) and finishings.		**X**
18	The water to cement ratio changes when fibres are incorporated in the mixture.	**X**	

19	Ordinary vibrators can be used for fibre reinforced concrete.	**X**	
20	Curing must be more careful with steel fibre reinforced concrete because the fibres cause the concrete surface to heat up more on hot days		**X**

Notes: